SICES®
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Parallel functions manual

- DST4602 - DST4602/P
- DST4602*Evolution* - DST4602/P*Evolution*
- GC500 - GC500*Plus* - GC500*Mains*
- GC400 - GC400*Mains* - GC400*Link*

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SUMMARY

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1. Introduction

This document is applicable to the following devices for the control of the generators (produced by **SICES Srl**):

- **DST4602**, **DST4602/P, DST4602^{Evolution}, DST4602/P^{Evolution}**
- **GC500, GC500^{Plus}, GC500^{Mains}**
- **GC400, GC400^{Mains}**, **GC400^{Link}**

In the rest of the document the term **GCU** ("Generator Control Unit") will be used to refer to all the boards, while the names **DST4602x** to refer to **DST4602, DST4602/P, DST4602^{Evolution}, DST4602/P^{Evolution}**, **GC500x** to refer to **GC500, GC500^{Plus}, GC500^{Mains}** and **GC400x** to refer to **GC400**, **GC400^{Mains}** and **GC500^{Link}**.

The specific name will be used in case of need to refer to the specific model of the controller.

GCUs manage the parallel of the generator with other generators and/or with the mains (or anyway with devices similar to electric mains - turbines, etc.).

The aim of this document is to describe all the functions that **GCU** provides for the management of the installations of parallel systems; it also describes how these functions can be configured through the programming parameters of **GCU**. Make however reference to **GCU** technical and operational manuals for everything not described in this manual.

1.1 Required knowledge

For proper use of this document it is required knowledge in using and commissioning gen-sets for parallel application.

It is also required the knowledge of basic control functions, which are explained in **GCU** operation manuals. Further explanations can be found in the technical manuals.

All these documents (programming parameter tables as well) should be considered an integral part of this manual.

1.2 Symbols and remarks

In this document a vertical bar on the right margin or a gray background indicates that the chapter or the paragraph has been amended respect to the previous document's version. Adjustments in tables fields are highlighted with a gray background.

1.3 Definitions

1.3.1 Anomalies

GCU is able to report and manage all the anomalous conditions occurring during the working of the system. The anomalies are classified into four categories, according to their severity and based on the actions **GCU** performs to manage them:

- **Warning.** This term is used to indicate an anomaly that, under the circumstances, doesn't compromise the working of the generator: the operator should, anyway, take note of it, because sooner or later it could worsen in a more serious anomaly.
- **Discharge**. This term is used to indicate an anomaly that requires the stop of generator. There aren't immediate risks either for the generator or for users. The intervention sequence is:

- If the generator is connected in parallel with another generator or with mains, **GCU** will provide to reduce gradually to zero the power supplied by the generator
- Then it opens the generator switch (**GCB**) and, if necessary, closes the mains switch (**MCB**, where provided, if it is not already closed).
- The engine is kept running for a configurable time (without load), to allow its cooling (cooling cycle).
- In the end **GCU** stops the engine.

- **Deactivation**. This term is used to indicate an anomaly that requires the stop of generator. There aren't immediate risks for generator, but there are potential risks for users, that, therefore, have to be disconnected immediately from generator. The intervention sequence is:
  - **GCU** immediately opens the generator switch (**GCB** , regardless the power supplied in that moment. If necessary it closes mains switch (**MCB**, where provided, if not already closed).
  - The engine is left in action for a configurable time (without load), to allow its cooling (cooling cycle).
  - In the end **GCU** stops the engine.
- **Alarm.** This term is used to indicate an anomaly that requires the stop of generator. There are immediate risks for the generator, that therefore, should be stopped immediately. The intervention sequence is:
  - **GCU** opens immediately the generator switch (**GCB**), regardless of the power supplied by the generator. If necessary it closes mains switch (**MCB**, where provided, if not already closed).
  - **GCU** stops the engine, without executing the cooling cycle.

1.3.2 Acronyms

AIF	Identifies a function for configuring analogue inputs (“Analogue Input Function”). The number that follows the wording “AIF.” represents the code to be set in the parameter that configures the function of the desired analogue input.
AOF	Identifies a function for configuring analogue outputs (“Analogue Output Function”). The number that follows the wording “AOF.” is the code to be set in the parameter that configures the function of the desired analogue output.
ADPs	Indicates the active power (kW) supplied by a generator.
ADPt	Indicates the active power (kW) supplied by all generators in parallel: it is the sum of the related ADPs.
BTB	This term identifies a switch (also called connector) used for connecting/separating two different parallel bars.
BTBCU	This term identifies a device to control a BTB switch (“BTB Control Unit”, for example BTB100).
CBE	Identifies the function “Closing Before Excitation” (quick parallel, see paragraph 7).
DIF	Identifies a function to configure digital inputs (“Digital Input Function”). The number that follows the wording “DIF.” represents the code that should be set in the parameter that configures the function of the desired digital input.
DOF	Identifies a function for the configuration of digital outputs (“Digital Output Function”). The number that follows the wording “DOF.” is the code that should be set in the parameter that configures the function of the desired digital output.
DPRt	Indicates the active power (%) supplied by all generators in parallel: it's the ratio between ADPt and MDPt values.

DPRtn	Indicates the active power (%) that generators in parallel would supply in case one of them (the one with less priority) came out from parallel.
EVT	Identifies an event stored within the historical records. The number that follows the wording “EVT.” is the event numeric code.
ESU	This term identifies a **SICES Srl**'s device (it can be a **GCU** or a **MCU**) that has special duties within the **PMCB** communication network . See 8.1.
GCB	This term identifies the switch that connects the generator to users (or to the parallel bars for systems with more than one generator) (“Generator Circuit Breaker”).
GCU	Indicates a device to control a generator (“Generator Control Unit”, for example **DST4602**).
GTS	Refer **MGCB**.
LOADt	Indicates the ratio between the values of RDPt and ADPt. It identifies the system total power load.
MCB	This term identifies the switch that connects mains to users (or to parallel bars if a switch **MGCB** doesn't exist) (“Mains Circuit Breaker”).
MCU	Indicates a device to control the mains (“Mains Control Unit”, for example **MC100**).
MDPs	Indicates the maximum active power (kW) that can be supplied by a single generator.
MDPt	Indicates the maximum active power (kW) that can be supplied by all generators in parallel. It is the sum of the related MDPs.
MDPtn	Indicates the maximum active power (kW) that can be supplied by all generators in parallel, except for the less priority one. It is the sum of the related MDPs.
MGCB	Indicates the switch that connects the parallel bars of the generator to users (“Master Generators Circuit Breaker”).
MPM	See the description of types of systems (par. 2).
MPtM	See the description of types of systems (par. 2).
MPtM + MSB	See the description of types of systems (par. 2).
MSB	See the description of types of systems (par. 2).
MSB + MSTP	See the description of types of systems (par. 2).
MTS	See **MCB**.
NECB	This term identifies the remote-control switch for the earthing of the neutral of the generator (“Neutral-Earth Circuit Breaker”).
PMCB	PMCB Identifies the communication bus (owner of **SICES SRL**) through which all devices share information in order to allow the parallel functions described in this document (“Power Management Communication Bus”).
RDPs	Indicates the reactive power (kvar) supplied by a generator (positive if the load is inductive).
RDPt	Indicates the reactive power (kvar) supplied by all generators in parallel: it is the sum of the related RDPs.
RESt	Difference (in kW) between the power supplied by generators and the maximum power they would be capable to supply.
REStn	Difference (in kW) between the power supplied by generators and the maximum power they would be capable to supply in case one of them (the lowest priority one) comes out from parallel.
SPM	See the description of types of systems (par. 2).
SPtM	See the description of types of systems (par. 2).
SPtM + SSB	See the description of types of systems (par. 2).
SSB	See the description of types of systems (par. 2).
SSB + SSTP	See the description of types of systems (par. 2).

1.4 References

[1] CAN open – Cabling and Connector Pin Assignment – CiA Draft Recommendation DR-303-1

[2] BOSCH CAN Specification – Version 2.0 – 1991, Robert Bosch Gmbh

[3] **SICES Srl** EAAM0380xxXA (**DST4602, DST4602/P, DST4602 Evolution, DST4602/P Evolution** parameter table).

[4] **SICES Srl** EAAM0391xxIT (**DST4602, DST4602/P, DST4602 Evolution, DST4602/P Evolution** technical manual).

[5] **SICES Srl** EAAS0394xxXA (**DST4602, DST4602/P, DST4602 Evolution, DST4602/P Evolution** Modbus registers).

[6] **SICES Srl** EAAM0322xxXA (**GC500/GC500Plus/GC500Mains** parameter table).

[7] **SICES Srl** EAAM0304xxIT (**GC500/GC500Plus/GC500Mains** technical manual).

[8] **SICES Srl** EAAS0454xxXA (**GC500/GC500Plus/GC500Mains** Modbus registers).

[9] **SICES Srl** EAAS0341xxIT (serial communication and SMS protocol).

[10] **SICES Srl** EAAS0117xxIT (Can Bus communication with engines).

[11] **SICES Srl** EAAS0425xxIT (Can Bus communication with engines).

[12] **SICES Srl** EAAM0504xxXA (parameter table **GC400/GC400*Link***).

[13] **SICES Srl** EAAM0456xxIT (technical manual **GC400/GC400*Link***).

[14] **SICES Srl** EAAS0505xxXA (Modbus registers **GC400/GC400*Link***).

[15] **SICES Srl** EAAS016412 (Bus communication for the management of the power in parallel systems)

2. Plant types

P.0802 parameter is the first and most important parameter that should be configured in the **GCU**, in order to establish operating logics of the system. It indeed identifies the type of system: through it **GCU** automatically enables or disables the required internal functions.

SICES Srl's GCUs manage ten different types of systems, divided into two categories: systems consisting of a single generator and systems composed of multiple generators. Within each category the systems are further subdivided according to the conditions necessary for the automatic operation of the generator. From this point of view three types of systems can be identified:

- Generator for "stand-alone" production only. The term "stand alone" indicates the situation in which one or more generators supply a load, without being in "parallel with mains". The automatic intervention of the generator is always required, regardless of the status of mains. Parallel with mains is not allowed.
- "Emergency" generator. The automatic intervention of the generator is required in case of failure of power mains. The parallel with mains is allowed, even if it is not the normal operation for this type of system.
- Generator for the production in "parallel with mains" only. The automatic intervention of the generator is required only if the power mains is present and within tolerance. "Stand-alone" supply is not allowed.

The following table shows a summary of the types of systems on the basis of what was said before:

P.0802	Stand-alone production.	Emergency.	Production in parallel with mains.	Number of generators.	Parallel with mains allowed.	Stand-alone supply allowed.
SPM	X			1	No	Yes
SSB		X		1	No	Yes
SSB + SSTP		X	X	1	Yes	Yes
SPtM			X	1	Yes	No
SPtM + SSB	X		X	1	Yes	Yes
MPM	X			>= 1	No	Yes
MSB		X		>= 1	No	Yes
MSB + MSTP		X	X	>= 1	Yes	Yes
MPtM			X	>= 1	Yes	No
MPtM + MSB	X		X	>= 1	Yes	Yes

The acronyms indicated in the first column will be described in detail below. It is important to understand the difference between the "**SSTP + SSB** " and "**SSB + SPtM**" systems: both in fact allow "stand-alone" supply and supply in "parallel with mains". The difference lies in the way through which the automatic intervention of the generator is required:

- "**SSB + SSTP**" is an "emergency" system and therefore the generator is started (automatically) only in case of failure of mains. To put the generator in parallel with mains, it is necessary to force it to start when mains is present (see2.3).
- "**SPtM + SSB**" is both a "stand-alone supplying" and supplying "in parallel with mains" system. In automatic mode the generator is started both when the mains is within tolerance and when it is out of tolerance or not present: in the first case the generator will supply in "parallel with mains", in the second the supplying will be "stand alone".

The same distinction applies to "**MSB + MSTP**" and "**MPTM + MSB**" systems. The different types of systems will be described in detail below.

Only for DST4602x and GC400x, it is possible to configure some digital outputs with DOF.0103 function (AND/OR logics) to indicate the type of selected system:

- Status ST.108: the output will be activated for emergency systems (**SSB** , **SSB + SSTP** , **MSB** , **M SB + MSTP**).
- Status ST.109: the output will be activated for systems in parallel with mains (**SSB + SSTP**, **SPtM**, **SPtM + SSB**, **MSB + MSTP**, **MPtM**, **MPtM + MSB**).
- Status ST.110: the output is activated for systems in parallel with other generators (**MPM**, **MSB**, **MSB + MSTP**, **MPtM**, **MPtM + MSB**).

Some GCUs manage just one part out of 10 listed plant types (see the parameter table of each controller to check which plants are managed by the device).

Note: the following description for the SSB plant is valid also for other SICES devices that do not manage the parallel function.

2.1 Inhibition to taking of load

In automatic mode, once the generator has been started, **GCU** normally always tries to close **GCB** switch. There are some exceptions:

- **SPtM** or **MPtM** systems (production in "parallel with mains" only): if mains voltages and frequency do not authorize the parallel (see3.2.1), **GCU** prevents **GCB** switch from closing and opening if it is closed. If within an appropriate time the mains does not come back "within tolerance", **GCU** stops the engine.
- Systems composed of multiple generators: when in parallel with another generator that fails to open its **GCB**, and P.0805 parameter was set to zero, **GCU** opens **GCB** switch.
- **GCU** in "**TEST**" mode: if P.0222 parameter is set to zero, **GCU** opens **GCB** switch.

In all other cases, **GCU** tries to close **GCB** switch: it is possible to force its opening by using the "inhibition to power load".

This internal function, once activated, has priority over any other function: **GCB** switch will be opened and it won't be possible to close it. Where provided, **GCU** will also close mains switch (**MCB**). The function operates in **AUTO**, **TEST** and **REMOTE START** modes. The activation of this function does not require the activation of anomalies on **GCU** and does not cause the stopping of the engine.

When this input is active, the inhibition to power load is active.

- By configuring a digital input with DIF.2502 (**DST4602x and GC400x**) or DIF.0030 functions (**only for GC500x**). When this input is active, the inhibition to power load is active.
- Through the controls of serial ports (see Modbus registers).
    - Holding register 20. By writing the value "20" into the register, the inhibition to power load is activated, by writing the value "21" it is disabled. This control remains active for 30 seconds from the time it is received by **GCU**: it is therefore necessary to repeat it about every 25 seconds until the inhibition to power load should be kept active.
    - **DST4602x and GC400x.** Holding register 101 e 102. It is first of all necessary to write the value configured with P.0004 parameter in register 101 (password): within 5 seconds; by writing the value "31" or "32" into the register 102 the inhibition to power load will be activated, by writing the value "33" it will be deactivated. The control remains active for 30 seconds from the time it is received by **GCU**: it is therefore necessary to repeat it about every 25 seconds until the inhibition to power load should be kept active.

Note: the command can be disabled by configuring a digital input with the function DIF.2706 (if that input is not enabled).

2.2 Inhibition to starting of the generator

In automatic mode, GCU determines, based on the type of system and the current conditions, whether or not to start the generator. Under these conditions, it is possible to force **GCU** to stop the generator by using the "inhibition to starting the generator".

This internal function, once activated, takes priority over any other function: the generator will be shut down and it will not possible to restart it. The function operates in **AUTO** mode, but not in **TEST** and **REMOTE START** modes. The activation of this function does not require the activation of anomalies.

When this input is active, the inhibition to power load is active.

- By configuring a digital input with DIF.2501 (**DST4602x and GC400x**) or DIF.0040 functions (for **GC500x**). When this input is active, the inhibition to start the generator is active.
- Using P.0421, P.0422 and P.0423 parameters it is possible to select the days of the week and a time frame within which the automatic intervention of the generator is allowed. Outside of that range (and in non-selected days), the function to inhibit the starting of the generator is active (and thus the generator will be stopped).

2.3 Forcing of intervention of the generator

Depending on the conditions of the system, **GCU** may automatically decide to stop the generator because its intervention is not required (for example, for emergency systems, when the mains is permanently within tolerance).

It is anyway possible to force the intervention of the generator even in these conditions, in two ways:

- By activating the **TEST** mode.
- By activating the **REMOTE START** mode.

2.3.1 Forcing of intervention in TEST mode

When the TEST mode has been activated, **GCU** always controls the starting of the generator (the function of inhibition of starting the generator is not active in this mode). With P.0222 parameter it is possible to configure whether **GCB** switch should be closed in TEST mode:

- P.0222 = 0: **GCB** switch should not be closed.
- P.0222 = 1: **GCB** switch should be closed, unless the function of "inhibition to power load" has been activated.

It is possible to activate the **TEST** mode in several ways:

- By configuring a digital input with DIF.2031 (**DST4602x and GC400x**) or DIF.0026 functions (for **GC500x**). When this input is active, **GCU** goes into TEST mode.
- Using P.0418 , P.0419 and P.0420 parameters, it is possible to select the days of the week and a time frame within which **GCU** goes into **TEST** mode.
- Through the controls of serial ports (see Modbus registers)
    - Holding register 20. By writing the value "6" into the register, **GCU** switches to **TEST**. **GCU** cancels this control if for a minute it does not receive messages on the serial port. By writing the value "7" into the same register, **GCU** comes back to **AUTO**. **DST4602x and GC400x**. Holding register 101 e 102. First of all it is necessary to write the value configured the P.0004 parameter in the register 101 (password): within 5 seconds, by writing the value "12" in the register 102 **GCU** switches to **TEST**. **GCU** cancels this control if for a minute it does not receive messages on the serial

port. By writing the value “21” with the same procedure, **GCU** comes back to **AUTO**. Note: the command can be disabled by configuring a digital input with the function DIF.2706 (if that input is not enabled).

- Through a **SMS** message (see [9]).
- Using **GCU** keys:
  - **DST4602x**: press START and ACK keys simultaneously to switch to TEST (press them again to go back to AUTO).
  - **GC500x and GC400x**: press START key to switch to TEST (press it again to go back to AUTO).

2.3.2 Forcing the intervention in REMOTE START mode

When the **REMOTE START** mode is active, **GCU** always controls the starting of the generator (the function of inhibition of starting the generator does not work in this mode); it also controls the closing of **GCB** switch, unless the function of "inhibition to power load" has been activated.

It is possible to activate the REMOTE START mode in several ways:

- By configuring a digital input with DIF.2032 (**DST4602x and GC400**) or DIF.0027 functions (for **GC500x**). When this input is active, **GCU** switches to REMOTE START mode (after the delay associated with the configured input).
- Through the controls of serial ports (see Modbus registers).
  - Holding register 20. By writing the value "18" into the register, **GCU** switches to REMOTE START. By writing the value "19" into the same register, **GCU** comes back to AUTO. **GCU** keeps this control even if serial communication is stopped.
    DST4602x and GC400x: Holding register 101 e 102. First of all it is necessary to write the value configured the P.0004 parameter in the register 101 (password): within 5 seconds, by writing the value "13" in the register 102 **GCU** switches to REMOTE START. By writing the value “21” with the same procedure, **GCU** comes back to AUTO. **GCU** keeps this control even if serial communication is stopped. Note: the command can be disabled by configuring a digital input with the function DIF.2706 (if that input is not enabled).
- Through a SMS message (see [9]).
- Using P.0426 , P.0427 and P.0428 parameters, it is possible to select the days of the week and a time frame within which **GCU** goes into **REMOTE START** mode. For **DST4602x** these parameters are available from the review 00.40. For **GC500x**, these parameters are available from the review 1.28.

2.4 Systems consisting of a single generator

For this category of systems the parallel with other generators is never allowed; their functions (distribution of active and reactive power, load management etc.) are not available.

As a rule, for these types of systems it is necessary to measure the voltage present at the user. It is instead important (with the exception of **SPM** system) to measure mains voltage and frequency, in order to determine its status to:

- Activate the generator for emergency service if mains is "out of tolerance".
- Determine whether the "parallel with mains" is authorized.

For these reasons, normally **GCU** mains/bar sensor is used as mains sensor. It is possible, but not mandatory, to configure a **GCU** digital input to acquire the status of "No voltage on parallel bars" (DIF.3102 function for **DST4602x and GC400x**, DIF.0050 function for **GC500x**). If this input is not

available, **GCU** determines the presence of voltage on the parallel bars (between **GCB** and **MCB**) based on the status (open/closed) of the two switches and at the presence of voltage on mains and generator.

It is anyway possible to use **GCU** mains/bars sensor to measure the voltage on parallel bars (although strongly advised against). In this case, as it is not possible to measure mains voltage directly, based on the type of system, two different contacts may be required:

- Status of the mains for emergency service (DIF.3101 for **DST4602x and GC400x**, DIF.0060 for **GC500x**). Required for **SSB** and **SSB + SSTP** systems.
- Status of "protections for the parallel with mains" (DIF.3103 **only for DST4602x**, DIF.0039 for **GC500x**). Required for **SSB + SSTP**, **SPtM** and **SPtM + SSB** systems.

Refer to **GCU** technical manual for the configuration of mains/bar sensors and for the configuration of digital inputs.

Feedback MGCB. Systems consisting of a single generator do not require the presence of **MGCB** switch, which is then completely ignored.

MCB and BTBCU devices. Control devices of mains and connectors are not managed for the systems consisting in a single generator (if a **MCU** is connected to a **GCU** configured with a "single" type of system, **GCU** activates A273 shutdown - inconsistent parameters).

Sequence:

The engine can be started only if **GCU** is not in OFF/RESET and if active shutdowns, deactivations and discharges are not present.

GCB switch, if controlled by **GCU**, can be closed only if the generator is running (see notes above), and if generator voltages and frequency of the are "within tolerance". See additional restrictions for the closing of **GCB** switch in the description of individual systems. The switch can always be opened.

DST4602x and GC400x: in case the stopping of the engine is required, **GCU** always makes at least one attempt of opening the switch before order its stopping.

2.4.1 SPM – "Single Prime Mover"

(Stand-alone single system)

See notes in 2.4 that applies to this system, too.

This is a stand-alone production system. It is the classic generator for building sites, where the operator decides when the generators should supply and when not. Parallel with mains is not allowed. Therefore it is never possible to perform the "power discharge" of the generator before opening the **GCB** switch: "discharge" anomalies therefore behave like "deactivations".

Main status. The status of the power mains is ignored for this type of system. At any rate, if mains is connected and **GCU** has been properly configured, frequency and voltage measurements are performed anyway.

MCB command. GCU does not handle **MCB** switch. P.0855 parameter should be configured as "2 - Controlled externally" (but is not mandatory, **GCU** behaves as if it were configured in this way). **MCB** key (or the combination SHIFT + **GCB** for some versions of **GC500, GC500*Plus*** **and GC400x**) is not used.

Feedback MCB. Any feedback is ignored.

GCB command P.0854 parameter allows configuring the way **GCU** manages the switch:

- P.0854 = 0: **GCB** controlled by **GCU**.

- P.0854 = 1: Incorrect value for this kind of system, **GCU** will act as if it were set on 0.
- **DST4602 and GC400x:** P.0854 = 2: **GCB** controlled externally.
- **DST4602 and GC400x:** P.0854 = 3: Incorrect value for this kind of system, **GCU** will act as if it were set on 2.

GCB key on the panel can be used in MAN to open and close the switch (if the switch is controlled by **GCU**).

Feedback GCB. Use DIF.3001 (**DST4602x and GC400x**) or DIF.0007 functions (for **GC500x**) to configure the input that acquires the feedback. It is not essential to acquire the feedback of **GCB** switch. If it is acquired, **GCU** uses it to:

- Correctly display the status of the switch.
- Only if a delay different from zero is set for the digital input that acquires the feedback, this delay is used as maximum opening/closing time of the same switch, with the aim to activate anomalies to report the failure of the switch.

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	Not available.
Synchronization for **MCB**.	Not available.
PMCB communication bus.	Not required.
Active power distribution.	Not available.
Distribution of reactive power.	Not available.
Protections for the parallel with mains.	Not available.
Power modulation in parallel with mains in BASE LOAD mode.	Not available.
Power modulation in parallel with mains in IMPORT/EXPORT mode.	Not available.
Adjusting of the power factor in parallel with mains.	Not available.
"Transfer to the generators" function.	Not available.
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

GCU prevents the closing of **GCB** switch if it acknowledges the presence of voltage on both sides of the switch (synchronization is not allowed for this type of system).

Manual sequence.

The operator can start/stop the generator with START and STOP keys.

If **GCB** switch is controlled by **GCU**, the operator can request its closing (under the conditions described above) or its opening with **GCB** key. If a delay for the digital input that acquires the switch feedback has been configured, **GCU** activates:

- W014 early warning in case of failed closing.
- W024 early warning in case of failed opening.

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no "starting inhibition" has been activated.
- In TEST and in REMOTE START: always ignoring “inhibitions to starting”.

DST4602x and GC400x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence W024 early warning is equivalent to a request for automatic intervention of the generator, which will be cancelled only when the operator acknowledges the early warning.

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. **GCB** switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.
- An "inhibition to power load" has been activated.
- In TEST, P.0222 parameter is set on 0.

The normal automatic operation logic (if **GCU** controls **GCB**) will be therefore:

1. **Engine stopped and GCB open.** If the automatic intervention of the generator is required, the procedure goes on from step 2.
2. **Engine starting**: wait status before voltage and frequency are within tolerance. Then the procedure goes on from step 3.
3. **GCB open.** If the generator should be stopped (shutdowns, deactivations, discharges, or if automatic intervention is no longer required), the procedure goes on from step 7. If there are requests for "inhibition to power load", the procedure remains at this point. Otherwise the procedure goes on from step 4.
4. **Closing of GCB** (three attempts): in case of failure to close, D014 deactivation (“**GCB** not closed”) will be activated and the procedure will go on from step 7.
5. **GCB closed.** In case of shutdowns, discharges or deactivations the procedure goes on from step 6. If there are requests for “inhibition to power load”, or if the automatic intervention of the generator is no more required, the procedure will go on from step 6.
6. **Opening of GCB** (three attempts): if the **GCB** is opened, the procedure goes on from step 3. If **GCB** is not opened:
    - **GC500x**: **GCU** activates A024 shutdown (**GCB** not open) and the procedure goes on from step 7.
    - **DST4602x and GC400x**: triggers W024 early warning (“**GCB** not open”). In case of shutdowns, deactivations or discharges, the engine should be stopped and therefore the procedure will go on from step 7. In the other cases, if **GCU** is configured to keep the generator in action in case of failure to opening of **GCB** switch (P.0243 = 1), the procedure will come back to step 5, otherwise will go on from step 7.
7. **Engine stop.**

2.4.2 SSB – "Single Stand By"

(Single emergency system)

See notes in 2.4 that applies to this system, too.

This kind of system provides only a generator that carries out emergency service to power mains. **GCU** provides to start the generator if the mains is "out of tolerance" from the configured time; it stops it if mains is "within tolerance" for the configured time. Parallel with mains is not allowed; so it is never possible to execute the "power discharge" of the generator before the opening **GCB** switch: therefore, "discharge" anomalies behave as "deactivations".

Main status. The mains status is fundamental for this kind of system, and it has to be obtained by **GCU** (if it isn't obtained, **GCU** considers mains always "out of tolerance" and provides to start the generator). Refer 2.4 to notes on the mains sensor.

MCB command P.0855 parameter allows the configuration of the way **GCU** has to manage the switch:

- P.0855 = 0: **MCB** controlled by **GCU**.
- P.0855 = 1: Incorrect value for this kind of system, **GCU** will act as if it were set on 0.
- P.0855 = 2: **MCB** controlled externally.
- **DST4602x and GC400x:** P.0855 = 3: Incorrect value for this kind of system, **GCU** will act as if it were set on 2.

The **MCB** key of the **GCU** panel (or the combination of keys **SHIFT** + **GCB** on **GC500, GC500*Plus*** **and GC400x**) can be used in MAN to open and close the switch (if controlled by **GCU**).

Feedback MCB. Use DIF.3002 (**DST4602x and GC400x**) or DIF.0006 functions (for **GC500x**) to configure the input that acquires the feedback. It isn't indispensable to connect the feedback of **MCB** switch. If it is connected, **GCU** uses it for:

- Correctly display the status of the switch.
- Prevent **GCB** from closing in case that **MCB** isn't open.
- It is possible to configure **GCU** (P.0221 > 0) in a way to make the generator intervene (automatically) also when mains is present, if **MCB** isn't closed and therefore users aren't supplied.
- Only if a delay different from zero is set for the digital input that acquires the feedback, this delay is utilized as opening/closing time-limit of the switch itself: in this case **GCU** reports failures of the switch by activating some anomalies.

DST4602x and GC400x: it is possible to use P.0847 parameter to indicate that, in case of mains failure, **MCB** switch will open automatically. In this way **DST4602x** can avoid activating early warning signals of "failure to close **MCB**" in the event of mains failure.

GCB command P.0854 parameter allows configuring the way **GCU** manages the switch:

- P.0854 = 0: **GCB** controlled by **GCU**.
- P.0854 = 1: Incorrect value for this kind of system, **GCU** will act as if it were set on 0.
- **DST4602x and GC400x:** P.0854 = 2: **GCB** controlled externally.
- **DST4602x and GC400x:** P.0854 = 3: Incorrect value for this kind of system, **GCU** will act as if it were set on 2.

The **GCB** key of the panel can be used in MAN mode to open and close the switch (if controlled by **GCU**).

Feedback GCB. Use DIF.3001 (**DST4602x and GC400x**) or DIF.0007 functions (for **GC500x**) to configure the input that acquires the feedback. It isn't indispensable to connect the feedback of **GCB** switch. If it is connected, **GCU** uses it for:

- Correctly display the status of the switch.
- Prevent **MCB** from closing in case that **GCB** isn't open.
- Only if a delay different from zero is set for the digital input that acquires the feedback, this delay is utilized as opening/closing time-limit of the switch itself: in this case **GCU** reports failures of the switch by activating some anomalies.

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	Not available.
Synchronization for **MCB**.	Not available.
PMCB communication bus.	Not required.
Active power distribution.	Not available.
Distribution of reactive power.	Not available.
Protections for the parallel with mains.	Not available.
Power modulation in parallel with mains in BASE LOAD mode.	Not available.
Power modulation in parallel with mains in IMPORT/EXPORT mode.	Not available.
Adjusting of the power factor in parallel with mains.	Not available.
"Transfer to the generators" function.	Not available.
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

GCB switch can be closed only when **MCB** is open: **GCU** prevents its closing when it acknowledges the presence of voltages on both sides of the switch (synchronization for **GCB** is not allowed).

Further notes on the sequence

MCB switch, if controlled by GCU, can be closed only if **GCB** switch is open: **GCU** prevents its closing when it acknowledges the presence of voltages on both sides of the switch (synchronization for MCB is not allowed). Usually it can be opened only with started engine and only to allow to close **GCB**.

In manual mode, **GCU** allows the opening of both switches.

Manual sequence.

The operator can start/stop the generator with START and STOP keys.

If **GCB** switch is controlled by **GCU**, the operator can request its closing (under the conditions described above) or its opening with **GCB** key. If the operator wants to close **GCB** while **MCB** is closed, **GCU**, first, will open **MCB** (if controlled by it) and then close **GCB**. Only when a delay for the digital input that acquires feedback of **GCB** switch has been configured, **GCU** activates:

- W014 early warning in case of failed closing.
- W024 early warning in case of failed opening.

If **MCB** switch is controlled by **GCU**, the operator can require opening or closing by means of **MCB** key (or with the combination of **SHIFT** + **GCB** keys for **GC500, GC500**^{Plus} and **GC400x**). If the operator wants to close **MCB** while **GCB** is closed, **GCU**, first, will open **GCB** (if controlled by it) and then close **MCB**. Only when a delay for the digital input that acquires feedback of **MCB** switch has been configured, **GCU** activates:

- W013 early warning in case of failed closing.
- W013 early warning in case of failed opening.

DST4602x and GC400x: to force the opening of the switch with stopped engine, **MCB** key should be pushed (or SHIFT + **GCB** for some version of **GC500** and **GC500Plus**) for 5 seconds.

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no “inhibition to starting” is activated and if mains is “out of tolerance”.
- In TEST and in REMOTE START: always ignoring “inhibitions to starting”.

By setting P.0221 parameter to a value different from 0, **GCU** will be configured to keep generator in supplying phase in case of failure (failure to closing) of **MCB** switch (if there aren't shutdowns, deactivations and discharges). In this case, the presence W013 early warning is equivalent to a request for automatic intervention of the generator, which will be cancelled only when the operator acknowledges the early warning.

DST4602x and GC400x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence W024 early warning is equivalent to a request for automatic intervention of the generator, which will be cancelled only when the operator acknowledges the early warning.

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. **GCB** switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.
- An "inhibition to power load" has been activated.
- In TEST, P.0222 parameter is set on 0.

MCB switch should be closed when **GCB** is open.

The normal AUTOMATIC operation logic (if **GCU** controls both switches) will be therefore:

1. **MCB closed, GCB open, engine stopped.** If the automatic intervention of the generator is required, the procedure goes on from step 2.
2. **Starting of the engine.** It attests that tension and frequency are within tolerance. Then the procedure goes on from step 3.
3. **MCB closed, GCB open.** If the generator should be stopped (shutdowns, deactivations, discharges, or if automatic intervention is no longer required), the procedure goes on from step 10. If there are requests for "inhibition to power load", the procedure waits at this point, otherwise it will go on from step 4.

4. **Opening of MCB** (three attempts): in case of failure to opening, D023 deactivation is activated ("**MCB** not open") and the procedure goes on from step 10. If the switch opens, the procedure goes on from step 5.

5. **MCB open, GCB open.** If the generator should be stopped (shutdowns, deactivations, discharges, or if automatic intervention is no longer required), the procedure goes on from step 9. If there are requests for "inhibition to power load", the procedure goes on from step 9. Otherwise the procedure goes on from step 6.

6. **Closing of GCB** (three attempts): in case of failure to close, D014 deactivation ("**GCB** not closed") will be activated and the procedure will go on from step 9. If the switch is closed, the procedure goes on from step 7.

7. **MCB open, GCB closed.** In case of shutdowns, discharges or deactivations the procedure goes on from step 8. If there are requests for "inhibition to power load", or if the automatic intervention of the generator is no more required, the procedure will go on from step 8.

8. **Opening of GCB** (three attempts). If the switch opens, the procedure goes on from step 5. If case of failed opening:

    - **Only for GC500x**: **GCU** activates A024 shutdown (**GCB** not open) and the procedure goes on from step 10.

    - **Only for DTS4602x: GCU**: triggers W024 early warning ("**GCB** not open"). If P.0243 parameter is set to 1, this early warning becomes a request for automatic intervention (until the operator recognizes the early warning). If there are shutdowns, discharges and deactivations the procedure goes on from step 10, otherwise it goes on from step 7.

9. **Closing of MCB** (three attempts): if the switch closes the procedure goes on from step 3. In case of failure to closing, **GCU** activates W013 early warning (**MCB** not closed): if P.0221 parameter is set on a value different from zero, this early warning becomes a request for automatic intervention (until the operator recognizes the early warning). If there are shutdowns, deactivation or discharges, the procedure goes on from step 10, otherwise it will come back to step 5.

10. **Engine stop.**

2.4.3 SSB + SSTP – "Single Stand By" + "Single Short Time Parallel"

(Single emergency system with fleeting parallel)

See notes in 2.4 that applies to this system, too.

This kind of system is very similar to the previous one: it provides a single generator that performs the emergency service to mains. **GCU** provides to start the generator if the mains is "out of tolerance" from the configured time; it stops it if mains is "within tolerance" for the configured time.

But unlike SSB system, **GCU** allows the parallel with mains.

Usually, the parallel with mains is temporary (P.0880=0): it is used to avoid a blackout on users during the switching of users from generator to mains (when mains comes back) or from mains to generator (in case of forced intervention in TEST or REMOTE START mode). In both cases, **GCU** synchronizes tensions, frequency and phase of generator with mains, closes a switch and within a time-limit opens another switch. The maximum duration of the parallel is 1 second: to use a longer time (but anyway limited), set the needed time in P.0890 parameter and set P.0880 to a value different from zero.

This kind of system also allows the continuative parallel with mains (if P.088 is different from zero). Usually this function is used to "test" the loaded engine (TEST), without anyway disconnecting users

from mains. In this case there isn't a limit to the duration of the parallel. Please refer to the paragraph 3 for all regulations that rules parallel with mains.

It's possible to indicate (by means of P.0854 and P.0855 parameters) whether synchronization should be used for closing **MCB**, for **GCB** switch or for both of them (it should be usable on at least one switch).

Main status. Mains status is fundamental for this kind of system (since it is an emergency system), and it should be obtained from **GCU**. It is used to activate the automatic intervention of the generator for the "emergency" service, but also to allow or not the "parallel with mains". Refer 2.4 to notes on the mains sensor.

MCB command P.0855 parameter allows the configuration of the way **GCU** has to manage the switch:

- P.0855 = 0: **MCB** controlled by **GCU**, synchronization not available.
- P.0855 = 1: **MCB** controlled by **GCU**, synchronization available.
- P.0855 = 2: **MCB** controlled externally, synchronization not available.
- **DST4602x and GC400x:** P.0855 = 3: **MCB** controlled externally, synchronization not available.

On **GC500x** value “3” is not available (instead value “2” is used)

If synchronization is required and **MCB** switch is controlled externally, a digital input for requiring the synchronization activation should exist (function DIF.1034 for **DST4602x and GC400x**, DIF.0052 for **GC500x**).

The **MCB** key of the **GCU** panel (or the combination of keys **SHIFT** + **GCB** on **GC500, GC500*Plus*** **and GC400x**) can be used in MAN to open and close the switch (if controlled by **GCU**).

Feedback MCB. Use DIF.3002 (**DST4602x and GC400x**) or DIF.0006 functions (for **GC500x**) to configure the input that acquires the feedback. Since the system allows parallel with mains, it's mandatory to connect the feedback of **MCB** switch. **GCU** uses it to:

- Correctly display the status of the switch.
- Determine the presence of voltage on the parallel bars, to decide whether the closing of switches can be done via synchronization.
- Recognize the status of "parallel with mains" and activate the appropriate adjusting methods of the active and reactive power.
- It is possible to configure **GCU** (P.0221 > 0) in a way to make the generator intervene (automatically) also when mains is present, if **MCB** isn't closed and therefore users aren't supplied.
- Since the system allows parallel with mains, anomalies regarding failure to opening and failure to closing of **MCB** switch are always managed. Sets a delay different from zero, for the digital input that acquires the feedback, this delay is used as the opening / closing time limit of the switch (otherwise a time limit of 2 seconds is used). **DST4602x and GC400x**: it is possible to use the P.0847 parameter to indicate to **GCU** that, in the event of a mains failure, **MCB** switch will open automatically. In this way, DSt4603 avoids activating early warning signals of "failure to close **MCB**" in the event of mains failure.

GCB command P.0854 parameter allows configuring the way **GCU** manages the switch:

- P.0854 = 0: **GCB** controlled by **GCU**, synchronization not available.
- P.0854 = 1: **GCB** controlled by **GCU**, synchronization available.
- **DST4602x and GC400x:** P.0854 = 2: **GCB** controlled externally, synchronization not available.

- **DST4602x and GC400x:** P.0854 = 3: **GCB** controlled externally, synchronization available.

If synchronization is required and **GCB** switch is controlled externally (**DST4602x and GC400x**), a digital input to require the activation of synchronization (DIF.1004 function) should exist.

The **GCB** key of the panel can be used in MAN mode to open and close the switch (if controlled by **GCU**).

Feedback GCB. Use DIF.3001 function (**DST4602x and GC400x**) or DIF.0007 function (only for **GC500x**) to configure the input that gets the feedback. Since the system allows parallel with mains, it's mandatory to connect the feedback of **GCB** switch. **GCU** uses it to:

- Correctly display the status of the switch.
- Determine the presence of voltage on the parallel bars, to decide whether the closing of switches can be done via synchronization.
- Recognize the status of "parallel with mains" and activate the appropriate adjusting methods of the active and reactive power.
- Since the system allows parallel with mains, anomalies regarding failure to opening and failure to closing of **GCB** switch are always managed. Sets a delay different from zero, for the digital input that acquires the feedback, this delay is used as the opening / closing time limit of the switch (otherwise a time limit of 2 seconds is used).

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	**Available if P.0854=1 or if P.0854 = 3.**
Synchronization for **MCB**.	**Available if P.0855=1 or if P.0855 = 3.**
PMCB communication bus.	Not required.
Active power distribution.	Not available.
Distribution of reactive power.	Not available.
Protections for the parallel with mains.	**Available**
Power modulation in parallel with mains in BASE LOAD mode.	**Available**
Power modulation in parallel with mains in IMPORT/EXPORT mode.	**Available**
Adjusting of the power factor in parallel with mains.	**Available**
"Transfer to the generators" function.	**Available**
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

If synchronization for **GCB** switch isn't allowed or isn't possible, the switch can be closed only if **MCB** is open.

Further notes on the sequence

MCB switch, if controlled by **GCU**, can always be closed. If synchronization for **MCB** is not enabled or not possible, the switch can be closed only if **GCB** is open. Normally **MCB** can be opened only with started engine, and only to allow the closing of **GCB**.

In manual mode, **GCU** allows the opening of both switches.

Manual sequence.

The operator can start/stop the generator with START and STOP keys.

If **GCB** switch is controlled by **GCU**, the operator can request its closing (under the conditions described above) or its opening with **GCB** key.

If the closing of the **GCB** is required:

- If **GCB** can be closed with synchronization, by pressing this key the synchronization function will be activated (see 5.4).
- If **GCB** cannot be closed with synchronization, **GCU** opens **MCB** (if not already open). Then, only if **MCB** is open, it controls the closing of **GCB**: in case of failure to close, it triggers W014 early warning.

If the closing of **GCB** is required:

- Whereas the generator isn't in parallel with mains: **GCU** activates the gradual power discharge; when the power of the set is lower than the power configured with P.0878 parameter (or at latest after P.0879 seconds), **GCU** will open **GCB** switch. If the key is held down for more than a second, **GCU** opens **GCB** switch immediately.
- Whereas the generator isn't in parallel with mains: **GCU** opens **GCB** switch immediately

If **MCB** switch is controlled by **GCU**, the operator can require opening or closing by means of **MCB** key (or with the combination of SHIFT + **GCB** keys for some version of **GC500** and **GC500*Plus*** **andGC400x**).

If the closing of the **MCB** is required:

- If **MCB** can be closed with synchronization, by pressing this key the synchronization function will be activated (see 5.4).
- If **MCB** cannot be closed with synchronization, **GCU** opens **GCB** (if not already open). Then, only if **GCB** is open, it controls the closing of **MCB**: in case of failure to close, it triggers W013 early warning.

If the opening of **MCB** switch is required by an operator, **GCU** opens it immediately (it is not possible to force a gradual transfer of power to the generator before opening the switch, if the generator is in parallel with mains).

DST4602x and GC400x: to open **MCB** switch with stopped engine, **MCB** key should be pushed (or with the combination of keys SHIFT + **GCB** on some version of **GC500** and **GC500Plus**) for 5 seconds.

If the keys to connect the generator in parallel with mains are used, but continuative parallel isn't allowed (P.0880 = 0), **GCU**, after the scheduled time-limit (see above), opens the switch closed from a longer time (when **GCB** closes, it opens **MCB** and vice versa).

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no “inhibition to starting” is activated and if mains is “out of tolerance”.
- In TEST and in REMOTE START: always, by ignoring "inhibitions to starting" and mains status.

By setting P.0221 parameter to a value different from 0, **GCU** will be configured to keep generator in supplying phase in case of failure (failure to closing) of **MCB** switch (if there aren't shutdowns, deactivations and discharges). In this case, the presence of W013 early warning

(**MCB** not closed) corresponds to a request for an automatic intervention of the generator, which will be annulled only when the operator recognizes the early warning.

By setting P.0221 parameter to value 2, **GCU** is configured to avoid blackout on users when mains come back, during commutation between mains and generator (if shutdowns, deactivations and discharges aren't present). In this case, the presence of W272 early warning (failure of parallel on **MCB**) corresponds to a request for automatic intervention of the generator, which will be annulled only when the operator recognizes the early warning

DST4602x and GC400x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence of W024 early warning (**GCB** not open) corresponds to a request for an automatic intervention of the generator, which will be annulled only when the operator recognizes the early warning

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. **GCB** switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.
- Protections for "parallel with mains" have been triggered, **MCB** is closed and **GCB** is configured as interface switch (P.0900 = 1, or anyway if MCB doesn't open within 0.5 seconds).
- An "inhibition to power load" has been activated.
- In TEST, P.0222 parameter is set on 0.

Moreover, it has to decide whether **MCB** switch has to be closed or not.

MCB shall be opened if protections for "parallel with mains" have been triggered, if **GCB** is closed and if **MCB** is configured as interface device (P.0900 = 2), or, anyway, if **GCB** doesn't open within 0.5 seconds.

MCB can be closed in the following cases:

- **GCB** open
- **GCB** closed, but only if
    - Tension and frequency of mains allow the parallel.
    - Synchronization for **MCB** is allowed.
    - There aren't shutdowns and deactivations.

  If all of the previous conditions are met, **MCB** can be closed:

    - If stop of generator is required.
    - If permanent parallel with mains is allowed (P.0880 > 0) and the function “Transfer to generators” is activated (DIF.2096).

The logic used by **GCU** ims to avoid, as far as is possible, blackouts on users. So, when possible, **GCU** always utilizes synchronization to close switches.

Moreover, **GCU** always try, when possible, to keep **MCB** switch closed. Therefore, if the continuative parallel with mains is allowed (P.0880 > 0) and if mains status authorizes parallel, **GCU** will always try to put generator in "parallel with mains". If, according to the previous conditions, **GCU** is forced to keep open **MCB** switch, it is necessary to use a digital input configured with DIF.2096 function (“Transfer to generators”).

The normal automatic operation logic (if **GCU** controls both switches) will be therefore:

1. **MCB closed, GCB open, engine stopped.** If the automatic intervention of the generator is required, the procedure goes on from step 2.

2. **Starting of the engine.** It attests that tension and frequency are within tolerance. Then the procedure goes on from step 3.

3. **MCB closed, GCB open.** If the generator should be stopped (shutdowns, deactivations, discharges, or if automatic intervention is no longer required), the procedure goes on from step 17. If there are requests for "inhibition to power load", the procedure waits at this point. Otherwise, it goes on from:

    - From step 4 if the synchronization for **GCB** is allowed (P.0854) and possible (mains status authorizes parallel).
    - From step 10 if **GCB** cannot be closed with synchronization.

4. **Closing with synchronization of GCB.** This phase lasts maximum P.0852 seconds. If the switch is closed, the procedure goes on from step 5. If **GCB** isn't closed within the time-limit, **GCU** will activate A271 shutdown (failed parallel on **GCB**) and the procedure goes on from step 17.

5. **MCB closed, GCB closed.** Here the generator is in parallel with mains. **GCU** should calculate the power setpoint for the generator:

    - P.0880 = 0. Continuative parallel with mains is not allowed. Power setpoint is 0 kW.
    - P.0881 = 1 (BASE LOAD). The power setpoint is P.0884 parameter (or a value acquired by the analogue inputs).
    - P.0881 = 2 (IMPORT/EXPORT). **GCU** calculates a power setpoint for the generator, so that power exchanged with the mains reaches the required value (P.0888).

    GCU controls the output of the generator to bring it to calculated value. If the request for "transfer to generators" is active (DIF.2096), when the generator power has reached the calculated value, the procedure goes on from step 8.

    If the continuative parallel with the mains is not allowed, elapsed the time-limit (see above) the procedure goes on from step 8.

    If the protections for the "parallel with the mains" have been triggered, the procedure goes on from step 7 when the interface device is **GCB** (P.0900 = 1), from step 8 when the interface device is **MCB** (P.0900 = 2)

    If the generator should to be stopped due to serious problems (shutdowns or deactivations), the procedure goes on from step 7.

    If the generator should be stopped due to other reasons (discharges, or if automatic intervention is no longer required), the procedure goes on from step 6.

    If an "inhibition to power load" is active, the procedure goes on from step 6.

6. **Power discharge.** The power of the generator is reduced to 0 kW with a rhythm that can be configured with P.0874 parameter (or P.0875 if there are discharges). This phase lasts until the power of the generator becomes lower than P.0878 threshold or after the time limit configured with P.0879. Then the procedure goes on from step 7.

    If the generator should to be stopped due to serious problems (shutdowns or deactivations), the procedure goes on from step 7.

    If the protections for the "parallel with the mains" have been triggered, the procedure goes on from step 7 when the interface device is **GCB** (P.0900 = 1), from step 8 when the interface device is **MCB** (P.0900 = 2)

7. **Opening of GCB with MCB closed** (three attempts).

   If the switch opens, the procedure goes on from step 3. If the protections for the "parallel with the mains" have been triggered and the interface switch is **GCB** (P.0900 = 1), if it is not opened within 0.5 seconds from the activation of protections, **GCU** activates A275 shutdown (interface switch not open) and the procedure goes on from step 9.

   In the other cases, GCU utilizes the normal time-out for the switch. If case of failed opening:

   - **DST4602x and GC400x**: **GCU**: triggers W024 early warning ("**GCB** not open"). If P.0243 parameter is set to 1, this early warning becomes a request for automatic intervention (until the operator recognizes the early warning). If there are shutdowns, discharges and deactivations the procedure goes on from step 17, otherwise it goes on from step 5.
   - **GC500x**: **GCU** activates A024 shutdown (**GCB** not open) and the procedure goes on from step 17.

8. **Opening of MCB with GCB closed** (three attempts).

   If the switch opens, the procedure goes on from step 13.

   If the protections for the "parallel with the mains" have been triggered and the interface switch is **MCB** (P.0900 = 2), if it is not opened within 0.5 seconds from the activation of protections, **GCU** activates A275 shutdown (interface switch not open) and the procedure goes on from step 9.

   In the other cases, GCU utilizes the normal time-out for the switch. In case of failure to opening, GCU will activate:

   - W023 early warning (**MCB** not open), but only if the continuative parallel with the mains is allowed (P.0880 > 0 - so that the generator can go on supplying).
   - Deactivation D023 (**MCB** not open) in the other cases.

   The procedure goes on from step 5.

9. **Opening of MCB and GCB together** (three attempts). This step of the procedure is executed only if shutdown A275 has been activated (interface switch not open). **GCU** remains in this status until **GCB** opens. Then the procedure goes on from step 17.

10. **Opening of MCB with GCB open** (three attempts): if the switch opens, the procedure goes on to step 12. In case of opening failure D023 deactivation is activated (**MCB** not open) and the procedure goes on with step 17.

11. **MCB open, GCB open.** If the generator should be stopped (shutdowns, deactivations, discharges, or if automatic intervention is no longer required), the procedure goes on from step 16. If there are requests for "inhibition to power load", the procedure goes on from step 16.

    If the mains status allows parallel and if it is possible to utilize the synchronization for **GCB**, the procedure goes on from step 16 (it will close **MCB** without synchronization, then it will close **GCB** with synchronization); otherwise it goes on from step 12.

12. **Closing of GCB without synchronization** (three attempts): in case of failure to closing D014 deactivation is activated (**GCB** not closed) and it goes on from step 16. If the switch is closed, the procedure goes on from step 13.

13. **MCB open, GCB closed.**

In case of shutdowns, discharges or deactivations the procedure goes on from step 15. If there are requests for "inhibition to power load" or if automatic intervention of the generator is no longer required, the procedure goes on from:

- Step 14 if the closing with synchronization of **MCB** is allowed (P.0855) and possible (a gap on users is avoided).
- Step 15 in other cases.

In case all the following conditions are met, the procedure goes on from step 14 (to set the generator in “parallel with the mains” again):

- Automatic intervention of the generator is still required.
- Continuative parallel to the mains is allowed (P.0880>0).
- Mains status authorizes parallel.
- The request for "transfer to generators" has not been activated (DIF.2096).
- The closing with synchronization of **MCB** is allowed (P.0855) and it's possible.
- W272 early warning isn't activated.

14. Closing of MCB with synchronization. This phase lasts maximum P.0853 seconds. If the switch is closed, the procedure goes on from step 5. If MCB isn't closed within the time-limit, **GCU** activates W272 early warning (failure to parallel on **MCB**). If P.0221 parameter is set to 2, this early warning becomes a request for automatic intervention (until it is recognized by the operator). The procedure goes on to:
    - Step 13 if the request for automatic intervention of the generator is still present and there aren't shutdowns, deactivations and discharges.
    - Step 15 in other cases.
15. **Opening of GCB with MCB open** (three attempts). If the switch opens, the procedure goes on from step 11. If case of failed opening:
    - **DST4602x and GC400x**: **GCU**: triggers W024 early warning (“**GCB** not open”). If P.0243 parameter is set to 1, this early warning becomes a request for automatic intervention (until the operator recognizes the early warning). The procedure goes on from step 13 if the request for the automatic intervention of the generator still exists and no shutdowns, deactivations and discharges are present, otherwise it goes on from step 17.
    - **GC500x**: **GCU** activates A024 shutdown (**GCB** not open) and the procedure goes on from step 17.
16. **Closing of MCB without synchronization** (three attempts): when **MCB** closes, the procedure goes on from step 3. If **MCB** doesn't close W013 early warning is activated (**MCB** not closed). If P.0221 parameter is set to a value different from zero, this early warning becomes a request for automatic intervention (until it is recognized by the operator).
    The procedure goes on from step 11 if the request for the automatic intervention of the generator still exists and no shutdowns, deactivations and discharges are present, otherwise it goes on from step 17.
17. **Engine stop.**

2.4.4 SPtM - "Single Parallel to Mains"

(Single parallel system to mains)

See notes in 2.4 that applies to this system, too.

This is a production system "in parallel with mains" only. **GCU** starts the generator when parallel is allowed by the status of the mains (see 3.2.1); it disconnects the generator when “protections for parallel with mains” are activated (see 3); it stops the generator when the status of the mains doesn't authorize parallel consecutively for P.0899 seconds.

The "stand-alone" supply is not allowed: therefore, if some "protections for parallel with mains" are activated, in any case **GCU** open the switch **GCB** , regardless the interface switch should be selected with the P.0900 parameter (see 3.3). Anyway, it's better to select **GCB** as interface switch (P.0900=1), to avoid useless openings of the switch **MCB**.

Parallel with mains should be continuative, so P.0880 parameter should be set to a value different from zero (otherwise **GCU** activates A273 shutdown “incoherent parameters”) and P.0890 parameter (maximum duration of parallel with mains) should be set to zero.

The function “transfer to generators” is not available, since stand-alone supply is not allowed.

Closing with synchronization of **GCB** switch (P.0854) should be possible: otherwise **GCU** activates A273 "inconsistent parameters" shutdown.

Please refer to the paragraph 3 for all regulations that rules parallel with mains.

Main status. The status of the power mains is critical for this kind of system and should be acquired by **GCU**. It is used to allow or not the “parallel with mains”. Refer 2.4 to notes on the mains sensor.

MCB command P.0855 parameter allows the configuration of the way **GCU** has to manage the switch:

- P.0855 = 0: **MCB** controlled by **GCU**, synchronization not available.
- P.0855 = 1: **MCB** controlled by **GCU**, synchronization available.
- P.0855 = 2: **MCB** controlled externally, synchronization not available.
- **DST4602x and GC400x:** P.0855 = 3: **MCB** controlled externally, synchronization not available.

On **GC500x** value “3” is not available (instead value “2” is used) Although **GCU** accepts any value, actually for this type of system it is never possible to close **MCB** with the synchronization: as a matter of fact, as the "stand-alone" supply is not allowed, it is never possible to have **GCB** closed with **MCB** open. Therefore, the values 1 and 3 should not be used for this type of system.

The **MCB** key of the **GCU** panel (or the combination of keys **SHIFT** + **GCB** on **GC500, GC500*Plus*** and **GC400x**) can be used in MAN to open and close the switch (if controlled by **GCU**).

Feedback MCB. Use DIF.3002 (**DST4602x and GC400x**) or DIF.0006 functions (for **GC500x**) to configure the input that acquires the feedback. Since the system allows parallel with mains, it's mandatory to connect the feedback of **MCB** switch. **GCU** uses it to:

- Correctly display the status of the switch.
- Recognize the status of "parallel with mains" and activate the appropriate adjusting methods of the active and reactive power.
- Since the system allows parallel with mains, the anomalies of failure to open and to close **MCB** are always managed. Sets a delay different from zero, for the digital input that acquires the feedback, this delay is used as the opening / closing time limit of the switch (otherwise a time limit of 2 seconds is used).

DST4602x and GC400x: it is possible to use the P.0847 parameter to indicate to **GCU** that, in the event of a mains failure, **MCB** switch will open automatically. In this way **GCU** avoids activating "failure to close **MCB**" early warnings of in the event of mains failure.

GCB command P.0854 parameter allows configuring the way **GCU** manages the switch:

- P.0854 = 0: Incorrect value for this type of system.
- P.0854 = 1: **GCB** controlled by **GCU**, synchronization available.
- **DST4602x and GC400x:** P.0854 = 2: Incorrect value for this type of system.
- **DST4602x and GC400x:** P.0854 = 3: **GCB** controlled externally, synchronization available.

If **GCB** is controlled externally (**DST4602x and GC400x**), a digital input to request the activation of the synchronization (DIF.1004 function) should exist.

The **GCB** key of the panel can be used in MAN mode to open and close the switch (if controlled by **GCU**).

Feedback GCB. Use DIF.3001 (**DST4602x and GC400x**) or DIF.0007 functions (for **GC500x**) to configure the input that acquires the feedback. Since the system allows parallel with mains, it's mandatory to connect the feedback of **GCB** switch. **GCU** uses it to:

- Correctly display the status of the switch.
- Recognize the status of "parallel with mains" and activate the appropriate adjusting methods of the active and reactive power.
- Since the system allows parallel with mains, the anomalies of failure to open and to close **GCB** are always managed. Sets a delay different from zero, for the digital input that acquires the feedback, this delay is used as the opening / closing time limit of the switch (otherwise a time limit of 2 seconds is used).

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	**Available**
Synchronization for **MCB**.	Not available.
PMCB communication bus.	Not required.
Active power distribution.	Not available.
Distribution of reactive power.	Not available.
Protections for the parallel with mains.	**Available**
Power modulation in parallel with mains in BASE LOAD mode.	**Available**
Power modulation in parallel with mains in IMPORT/EXPORT mode.	**Available**
Adjusting of the power factor in parallel with mains.	**Available**
"Transfer to the generators" function.	Not available.
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

GCB switch can only be closed if **MCB** is closed and if the status of the mains authorizes the parallel. It can therefore be closed only with synchronization.

Further notes on the sequence

MCB switch, if controlled by **GCU**, can always be closed. Since the "stand-alone" supply is not available, **MCB** can be closed only without synchronization, and then only if **GCB** is open. Normally **MCB** can be opened only if it is selected as "interface switch" (P.0900) and if the protections for the "parallel with mains" are triggered.

In manual mode, **GCU** allows the opening of both switches.

Manual sequence.

The operator can start/stop the generator with START and STOP keys.

If **GCB** switch is controlled by **GCU**, the operator can request its closing (under the conditions described above) or its opening with **GCB** key. If it requires the closing of **GCB** switch, by pressing this button the synchronization function will be activated (see 5.4). If it requires the opening of **GCB**, by pressing this key the gradual unloading of the power will be activated; when the power of the generator is lower than the configuration with P.0878 parameter (or at the latest after P.0879 seconds), **GCU** will open **GCB** switch. If the key is held down for more than a second, **GCU** opens **GCB** switch immediately. In case of failure to open, **GCU** activates W024 early warning.

If **MCB** switch is controlled by **GCU**, the operator can require opening or closing by means of **MCB** key (or with the combination of **SHIFT** + **GCB** keys for some version of **GC500** and **GC500*Plus*** **and GC400x**). The closing of **MCB** is possible only without synchronization (i.e. with open **GCB**): in case of failed closing, **GCU** activates W013 early warning. If the opening of **MCB** switch is required, **GCU** opens it immediately (in case of failure to open it activates W023 early warning), and also immediately opens **GCB** switch, since it is not possible to supply stand alone.

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no "inhibition to starting" is active and if the status of the mains authorizes the parallel with mains.
- In TEST and in REMOTE START: always, by ignoring "inhibitions to starting" and mains status.

DST4602x and GC400x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence of W024 early warning (**GCB** not open) corresponds to a request for an automatic intervention of the generator, which will be annulled only when the operator recognizes the early warning

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. **GCB** switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.
- The protections for the "parallel with mains" have been triggered.
- The status of the mains does not authorize parallel.
- An "inhibition to power load" has been activated.
- In TEST, P.0222 parameter is set on 0.

Moreover, it has to decide whether **MCB** switch has to be closed or not. **MCB** is always closed, except in case it is configured as "interface device" (P.0900 = 2) and **GCB** switch is closed and the protections for the "parallel with mains" have been triggered.

The normal automatic operation logic (if **GCU** controls both switches) will be therefore:

1. **MCB closed, GCB open, engine stopped.** If the automatic intervention of the generator is required, the procedure goes on from step 2.

2. **Starting of the engine.** It attests that tension and frequency are within tolerance. Then the procedure goes on from step 3.

3. **MCB closed, GCB open.** If the generator should be stopped (shutdowns, deactivations, discharges, or if automatic intervention is no longer required), the procedure goes on from step 11. If there are requests for "inhibition to power load", the procedure waits at this point. Otherwise, it goes on from step 4.

4. **Closing with synchronization of GCB.** This phase lasts maximum P.0852 seconds. If the switch is closed, the procedure goes on from step 5. If **GCB** isn't closed within the time-limit, **GCU** will activate A271 shutdown (failed parallel on **GCB**) and the procedure goes on from step 11.

5. **MCB closed, GCB closed.** Here the generator is in parallel with mains. **GCU** should calculate the power setpoint for the generator:

   - P.0881 = 1 (BASE LOAD). The power setpoint is P.0884 parameter (or a value acquired by the analogue inputs).
   - P.0881 = 2 (IMPORT/EXPORT). **GCU** calculates a power setpoint for the generator, so that power exchanged with the mains reaches the required value (P.0888).

   GCU controls the output of the generator to bring it to the calculated setpoint.

   If the protections for the "parallel with the mains" have been triggered, the procedure goes on from step 7 when the interface device is **GCB** (P.0900 = 1), from step 8 when the interface switch is **MCB** (P.0900 = 2)

   If the generator should to be stopped due to serious problems (shutdowns or deactivations), the procedure goes on from step 7.

   If the generator should be stopped due to other reasons (discharges, or if automatic intervention is no longer required), the procedure goes on from step 6.

   If an "inhibition to power load" is active, the procedure goes on from step 6.

6. **Power discharge.** The power of the generator is reduced to 0 kW with a rhythm that can be configured with P.0874 parameter (or P.0875 if there are discharges). This phase lasts until the power of the generator becomes lower than P.0878 threshold or after the time limit configured with P.0879. Then the procedure goes on from step 7. If in the meantime shutdowns or disconnections have been triggered, the procedure goes on directly from step 7. Instead, if protections for "parallel with mains" have been triggered, the procedure goes on from step 7 or 8 (depending on which switch is the interface device – P.0900).

7. **Opening of GCB with MCB closed** (three attempts). If the switch opens, the procedure goes on from step 3.
   If the protections for the "parallel with mains" have been triggered and the interface switch is **GCB** (P.0900 = 1), if it is not opened within 0.5 seconds, **GCU** activates A275 shutdown (interface switch not open) and goes on from step 8.
   Instead, if protections for the "parallel with mains" have not been triggered, **GCU** waits for the normal time-out of the switch, and in the event of failure to open:

- **DST4602x and GC400x**: **GCU**: triggers W024 early warning ("**GCB** not open"). If P.0243 parameter is set to 1, this early warning becomes a request for automatic intervention (until the operator recognizes the early warning). If there are shutdowns, discharges and deactivations the procedure goes on from step 11, otherwise it goes on from step 5.

- **GC500x**: **GCU** activates A024 shutdown (**GCB** not open) and the procedure goes on from step 11.

8. **Opening of MCB and GCB together** (three attempts). This step of the procedure is executed only if the interface switch is **MCB**. If it does not open within 0.5 seconds from the triggering of protection for the "parallel with mains", **GCU** activates A275 shutdown (interface switch not open). In any case **GCU** remains in this status until **GCB** opens. If it opens, the procedure goes on:

   - From step 9 if **MCB** has been already opened.

   - From step 3 is **MCB** is still closed.

   If **GCB** is not opened, **GCU** activates A024 shutdown (**GCB** not open).

9. **MCB open, GCB open.** The procedure however goes on from step 10, because there is no reason to keep **MCB** open.

10. **Closing of MCB without synchronization** (three attempts): when **MCB** closes, the procedure goes on from step 3. If **MCB** doesn't close W013 early warning is activated (**MCB** not closed). The procedure comes back to step 8 if the request for automatic intervention of the generator is still present and there are no shutdowns, deactivations and discharges; otherwise it goes on from step 11.

11. **Engine stop.**

2.4.5 SPtM + SSB – "Single Parallel to Mains" + "Single Stand By"

(Single parallel system to mains with possibility to operate stand alone as well)

See notes in 2.4 that applies to this system, too.

In this type of system, the generator can deliver both "stand alone" and in "parallel with mains". It is very similar to system SSB + SSTP. The differences with reference to it are:

- This system is not an emergency system; then the request for automatic triggering of the generator is not linked to the status of the mains.

- The continuative parallel with mains (P.0880 > 0) should be allowed, otherwise **GCU** activates A273 "inconsistent parameters" shutdown.

If there are no "inhibitions to starting" **GCU** starts the generator. Then it closes **GCB** switch:

- With synchronization if the status of the mains authorizes the parallel (see 3).

- Without synchronization (opening **MCB** first) to supply "stand alone".

The closing with synchronization of at least one switch (preferably both) should be possible: otherwise **GCU** activates A273 "inconsistent parameters" shutdown.

As the stand-alone supply is allowed, it is preferable (but not mandatory) to select **MCB** as interface switch (P.0900= 2).

Please refer to the paragraph 3 for all regulations that rules parallel with mains.

Main status. The status of the power mains is critical for this kind of system and should be acquired by **GCU**. It is used to allow or not the "parallel with mains". Refer 2.4 to notes on the mains sensor.

MCB command P.0855 parameter allows configuring how **GCU** manages **MCB** switch:

- P.0855 = 0: **MCB** controlled by **GCU**, synchronization not available.
- P.0855 = 1: **MCB** controlled by **GCU**, synchronization available.
- P.0855 = 2: **MCB** controlled externally, synchronization not available.
- **DST4602x and GC400x:** P.0855 = 3: **MCB** controlled externally, synchronization not available.

On **GC500x**, the value "3" is not available (the value "2" is used instead).

If synchronization is required and **MCB** is controlled externally, a digital input to request activation of the synchronization (DIF.1034 function for **DST4602x and GC400x**, DIF.0052 function for **GC500x**) should exist.

The **MCB** key of the **GCU** panel (or the combination of keys **SHIFT** + **GCB** on **GC500, GC500*Plus*** **and GC400**) can be used in MAN to open and close the switch (if controlled by **GCU**).

Feedback MCB. Use DIF.3002 (**DST4602x and GC400x**) or DIF.0006 functions (for **GC500x**) to configure the input that acquires the feedback. Since the system allows the parallel with mains, it is essential to connect the feedback of **MCB** switch. **GCU** uses it to:

- Correctly display the status of the switch.
- Determine the presence of voltage on the parallel bars, to decide whether the closing of switches can be done via synchronization.
- Recognize the status of "parallel with mains" and activate the appropriate adjusting methods of the active and reactive power.
- Since the system allows parallel with mains, the anomalies of failure to open and to close **MCB** are always managed. Sets a delay different from zero, for the digital input that acquires the feedback, this delay is used as the opening / closing time limit of the switch (otherwise a time limit of 2 seconds is used).

DST4602x and GC400x: It is possible to use P.0847 parameter to indicate to **GCU** that, in the event of mains failure, **MCB** switch will open automatically. In this way **GCU** avoids activating "failure to close **MCB**" early warnings of in the event of mains failure.

GCB command P.0854 parameter allows configuring how **GCU** manages **GCB** switch:

- P.0854 = 0: **GCB** controlled by **GCU**, synchronization not available.
- P.0854 = 1: **GCB** controlled by **GCU**, synchronization available.
- **DST4602x and GC400x:** P.0854 = 2: **GCB** controlled externally, synchronization not available.
- **DST4602x and GC400x:** P.0854 = 3: **GCB** controlled externally, synchronization available.

If synchronization is required and **GCB** is controlled externally (**DST4602x and GC400x**), a digital input to request the activation of the synchronization (DIF.1004 function) should exist.

The **GCB** key of the panel can be used in MAN mode to open and close the switch (if controlled by **GCU**).

Feedback GCB. Use DIF.3001 (**DST4602x and GC400x**) or DIF.0007 functions (for **GC500x**) to configure the input that acquires the feedback. Since the system allows the parallel with mains, it is to connect the feedback of **GCB** switch. **GCU** uses it to:

- Correctly display the status of the switch.

- Determine the presence of voltage on the parallel bars, to decide whether the closing of switches can be done via synchronization.
- Recognize the status of "parallel with mains" and activate the appropriate adjusting methods of the active and reactive power.
- Since the system allows parallel with mains, the anomalies of failure to open and to close **GCB** are always managed. Sets a delay different from zero, for the digital input that acquires the feedback, this delay is used as the opening / closing time limit of the switch (otherwise a time limit of 2 seconds is used).

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	**Available**
Synchronization for **MCB**.	**Available**
PMCB communication bus.	Not required.
Active power distribution.	Not available.
Distribution of reactive power.	Not available.
Protections for the parallel with mains.	**Available**
Power modulation in parallel with mains in BASE LOAD mode.	**Available**
Power modulation in parallel with mains in IMPORT/EXPORT mode.	**Available**
Adjusting of the power factor in parallel with mains.	**Available**
"Transfer to the generators" function.	**Available**
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

If synchronization for **GCB** is not enabled or not possible, the switch can be closed only if **MCB** is open.

Further notes on the sequence

MCB switch, if controlled by **GCU**, can always be closed. If synchronization for **MCB** is not enabled or not possible, the switch can be closed only if **GCB** is open. Normally **MCB** can be opened only with started engine, and only to allow the closing of **GCB** for the "stand-alone" supply.

In manual mode, **GCU** allows the opening of both switches.

Manual sequence.

The operator can start/stop the generator with START and STOP keys.

If **GCB** switch is controlled by **GCU**, the operator can request its closing (under the conditions described above) or its opening with **GCB** key.

If the closing of the **GCB** is required:

- If **GCB** can be closed with synchronization, by pressing this key the synchronization function will be activated (see 5.4).

- If **GCB** cannot be closed with synchronization, **GCU** opens **MCB** (if not already open). Then, only if **MCB** is open, it controls the closing of **GCB**: in case of failure to close, it triggers W014 early warning.

If the opening of **GCB** is required:

- Whereas the generator isn't in parallel with mains: **GCU** activates the gradual power discharge; when the power of the generator is lower than the power configured with P.0878 parameter (or at latest after P.0879 seconds), **GCU** will open **GCB** switch. If the key is held down for more than a second, **GCU** opens **GCB** switch immediately.
- Whereas the generator isn't in parallel with mains: **GCU** opens **GCB** switch immediately

In case of failure to open, activates W024 early warning.

If **MCB** switch is controlled by **GCU**, the operator can require opening or closing by means of **MCB** key (or with the combination of **SHIFT** + **GCB** keys for **GC500**, **GC500^{Plus} and GC400x**).

If the closing of the **MCB** is required:

- If **MCB** can be closed with synchronization, by pressing this key the synchronization function will be activated (see 5.4).
- If **MCB** cannot be closed with synchronization, **GCU** opens **GCB** switch (if not already open). Then, only if **GCB** is open, it controls the closing of **MCB**: in case of failure to close, it triggers W013 early warning.

If the opening of MCB is required, GCU opens it immediately (it is not possible to force a gradual transfer of power to the generator before opening the switch, if the generator is in parallel with mains). In case of failure to open, **GCU** activates W023 early warning.

DST4602x and GC400x: to open **MCB** switch with stopped engine, press the key for 5 seconds.

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no "starting inhibition" has been activated.
- In TEST and in REMOTE START: always ignoring “inhibitions to starting”.

DST4602x and GC400x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence of W024 early warning (**GCB** not open) corresponds to a request for an automatic intervention of the generator, which will be annulled only when the operator recognizes the early warning.

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. **GCB** switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.
- The protections for the "parallel with mains" have been triggered, **MCB** is closed and **GCB** is the interface switch (or anyway if MCB does not open within 0.5 seconds).
- An "inhibition to power load" has been activated.
- In TEST, P.0222 parameter is set on 0.

Moreover, it has to decide whether **MCB** switch has to be closed or not. **MCB** is always closed, except if:

- It is configured as "interface device" (P.0900 = 2), when **GCB** switch is closed and the protections for the "parallel with mains" have been triggered.
- The "transfer to generators" mode (DIF.2096) has been activated

See **SSB + SSTP** system for exemplificative sequence.

2.5 Systems consisting of more than one generator

All the following systems require the use of one or more generators that work in parallel among them.

For these types of systems it is possible (but not mandatory) to use **MCU** devices to manage the mains (both for emergency functions and for "parallel with mains" protections) and **MCB** and **MGCB** switches. If **MCUs** are used, it is not necessary to connect the feedbacks of **MCB** and **MGCB** to the digital inputs of **GCUs**, since all information is shared on **PMCB** network.

For these types of systems, it should always be possible to use synchronization to close **GCB** switch. It is possible to use the internal synchronizer of **GCU**, or an external synchronizer. To use the internal synchronizer, it is necessary to connect parallel bars to mains sensor/**GCU** bars.

Main status. If mains sensor/**GCU** bars are used for parallel bars, **GCU** will no longer be able to directly acquire the status of the mains necessary for all systems except for MPM). It will therefore be necessary to install external devices for this purpose. These devices can be:

- **MCU** by **SICES Srl** (in this case nothing else is required).
- Other devices. They will have to provide output contacts (to be connected to **GCU** digital inputs) that indicate the status of the mains. Depending on the type of system, two different connections could be required:
  - Status of the mains for emergency service (DIF.3101 for **DST4602x and GC400x**, DIF.0060 for **GC500x**). Required for **MSB** and **MSB + MSTP** systems.
  - Status of the "protections for the parallel with mains" (DIF.3103 for **DST4602x and GC400x**, DIF.0039 for **GC500x**). Required for **MSB + MSTP** , **MPtM** and **MPtM + MSB** systems:

It is anyway possible to use mains sensor/**GCU** bars as mains sensor. In this case it is however necessary to:

- Use an external synchronizer to close **GCB** (both for controlling speed/voltage and to consent closing).
- Use a digital input of **GCU** to acquire the status of "No voltage on parallel bars" (DIF.3102 for **DST4602x and GC400x**, DIF.0050 for **GC500x**).

Refer to **GCU** technical manual for the configuration of mains sensor/bars and for the configuration of digital inputs.

MCB command for these systems, **GCU** never controls **MCB** switch (which should always be "controlled externally"). The possible values for P.0855 parameter are:

- P.0855 = 0: Incorrect value for this type of system.
- P.0855 = 1: Incorrect value for this type of system.
- P.0855 = 2: **MCB** controlled externally, synchronization not available.
- **DST4602x and GC400x:** P.0855 = 3: **MCB** controlled externally, synchronization not available.

On **GC500x,** the value “3” is not available (the value “2” is used instead)

For **MSB + MSTP** and **MSB + MPtM** systems the synchronization for the closing of **MCB** (P.0855= 3) may be required. In this case an external synchronizer (both for controlling speed/voltage and to consent closing) is mandatory required. It is possible to:

- Use a **MCU** (in this case nothing else is required).
- Use an external synchronizer:
  - Connect the synchronization request for the closing of **MCB** to a digital input of all **GCUs** (in parallel) (DIF.1034 for **DST4602x and GC400x**, DIF.0052 for **GC500x**). Use separation diodes, see **GCU** technical manual for parallel connection of digital inputs.
  - If an analogue synchronizer is used, it should be connected (in parallel) to an analogue input of all the **GCUs**. In this case it is necessary to:
    - **DST4602x**. Configure the analogue input with AIF.2104 function and use P.0817 and P.0818 parameters for input scaling. Alternatively, use AIF.2105 function and use a conversion curve for scaling (see **GCU** technical manuals).
    - **GC400x**. Use the function AIF.2105 and use a conversion curve for scaling (see **GCU** technical manuals).
    - **GC500x**. Select the required analogue input with P.0833 parameter and use P.0835 and P.0836 parameters for input scaling.
  - To use a digital (UP/DOWN) synchronizer it is necessary to:
    - Use an external DIPOT module produced by **SICES Srl** to convert UP/DOWN controls into an analogue signal to be managed as indicated above.
    - **DST4602x**: use "Digital Potentiometer" function provided by the internal PLC to convert the UP/DOWN controls into an analogue value. This value should be stored in a virtual analogue input to be managed as indicated above.

MCB key (or the combination **SHIFT** + **GCB** for **GC500, GC500*Plus*** **and GC400x**) is not used.

Feedback MCB. For systems that require the "parallel with mains" **GCU** has to acquire the status of mains switch. For MSB system it is optional. The acquisition of this status can be performed:

- Through a **MCU** (in this case nothing else is required).
- Through a digital input of **GCU** (DIF.3002 for **DST4602x and GC400x**, DIF.0006 for **GC500x**).

If acquired, **GCU** uses it to:

- Correctly display the status of the switch.
- For **MSB** system: **GCU** prevents **GCB** switch from closing if mains is connected to the parallel bars (and forces its opening if it is closed).
- For **MSB + MSTP**, **MPtM** and **MPtM + MSB** systems: GCU recognizes the status of "in parallel with mains" and activates all active and reactive power management functions. Moreover it manages the status of the protections for the "parallel with mains" in order to open **GCB** if they have been activated (as interface device or in case as backup device).

- Since **MCB** is controlled externally, **GCU** cannot manage faults regarding failure to open and close.

Feedback MGCB. If **MGCB** switch does not exist, no action is required. If **MGCB** exists, for the systems that involve a "parallel with mains" **GCU** should acquire its status. For MSB system it is optional.

The acquisition of this status can be performed:

- Through a **MCU** (in this case nothing else is required).
- Through a digital input of **GCU** (DIF.3003 for **DST4602x and GC400x**, DIF.0036 for **GC500x**).

If acquired, **GCU** uses it to:

- Correctly display the status of the switch.
- To enable the "load management", if mains is not connected to parallel bars: the functions automatically start/stop the generators according to the size of the load to be supplied.
- For **MSB** system: **GCU** prevents **GCB** switch from closing if mains is connected to the parallel bars (and forces its opening if it is closed).
- For **MSB + MSTP**, **MPtM** and **MPtM + MSB** systems: GCU recognizes the status of "in parallel with mains" and activates all active and reactive power management functions. Moreover it manages the status of the protections for the "parallel with mains" in order to open **GCB** if they have been activated (as interface device or in case as backup device).

GCB command P.0854 parameter allows configuring the way **GCU** manages the switch:

- P.0854 = 0: Incorrect value for this type of system.
- P.0854 = 1: **GCB** controlled by **GCU**, synchronization available.
- **DST4602x and GC400x:** P.0854 = 2: Incorrect value for this type of system.
- **DST4602x and GC400x:** P.0854 = 3: **GCB** controlled externally, synchronization available.

If an incorrect value is set, **GCU** activates A273 alarm (inconsistent parameters).

If **GCB** is controlled externally (**DST4602x and GC400x**), a digital input to request the activation of the synchronization (DIF.1004 function) should exist.

GCB key on the panel can be used in MAN to open and close the switch (if the switch is controlled by **GCU**).

Feedback GCB. Use DIF.3001 (**DST4602x and GC400x**) or DIF.0007 functions (for **GC500x**) to configure the input that acquires the feedback. As it is a parallel system, it is mandatory to connect the feedback of **GCB** switch. **GCU** uses it to:

- Correctly display the status of the switch.
- Recognize the condition of "parallel with other sets" and activate active and reactive power management functions.
- For **MSB + MSTP**, **MPtM** and **MPtM + MSB** systems: GCU recognizes the status of "in parallel with mains" and activates all active and reactive power management functions. It also manages the status of protections for the "parallel with mains" in order to open **GCB** if they are triggered (as interface device or in case as backup device).

- Being a parallel system, failures to open of close **GCB** are always managed. Sets a delay different from zero, for the digital input that acquires the feedback, this delay is used as the opening / closing time limit of the switch (otherwise a time limit of 2 seconds is used).

Sequence:

The engine can be started only if **GCU** is not in OFF/RESET and if there are no shutdowns, deactivations and discharges.

GCB switch, if controlled by **GCU**, can be closed only if the generator is running (see notes above), and if generator voltages and frequency are "within tolerance". See additional restrictions for the closing of **GCB** in the description of individual systems. The switch can always be opened.

DST4602x and GC400x: in case the stopping of the engine is required, **GCU** always makes at least one attempt of opening the switch before order its stopping.

Manual sequence.

The operator can start/stop the generator with START and STOP keys.

If **GCB** switch is controlled by **GCU**, the operator can request its closing (under the conditions described above) or its opening with **GCB** key.

If the closing of the **GCB** is required:

- If GCB can be closed with synchronization (presence of voltage on parallel bars), by pressing this key the synchronization function will be activated (see 5.4).
- If **GCB** can be closed without synchronization (not possible for **MPtM** system), **GCU** controls the direct closing of **GCB**: in case of failure to close it activates W014 early warning.

If the opening of **GCB** is required:

- While the generator is in parallel with mains or with another generator which in its turn is not coming out of the parallel: **GCU** activates gradual power discharge. When the power of the generator is lower than the one configured with P.0878 parameter (or at latest after P.0879 seconds), **GCU** will control the opening of the **GCB**. If the key is held down for more than a second, **GCU** opens **GCB** switch immediately.
- While the generator is not in parallel with mains or other generators: **GCU** opens **GCB** switch immediately

In case of failure to open, activates W024 early warning.

2.5.1 MPM – "Multiple Prime Mover"

(Multiple stand-alone production system)

See notes in 2.5 that applies to this system, too.

This type of system provides for the only "stand-alone" production They are the classic generators for building sites, where the operator decides when the generators should supply and when not. Parallel with mains is not allowed.

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	**Available**
Synchronization for **MCB**.	Not available.

PMCB communication bus.	**Required.**
Active power distribution.	**Available**
Distribution of reactive power.	**Available**
Protections for the parallel with mains.	Not available.
Power modulation in parallel with mains in BASE LOAD mode.	Not available.
Power modulation in parallel with mains in IMPORT/EXPORT mode.	Not available.
Adjusting of the power factor in parallel with mains.	Not available.
"Transfer to the generators" function.	Not available.
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no "starting inhibition" has been activated. NOTE: the "load management" (see 8.6) can activate the "inhibition to starting" for the generators which should be stopped because not needed to support the load.
- In TEST and in REMOTE START: always ignoring “inhibitions to starting”.

DST4602x and GC400x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence W024 early warning is equivalent to a request for automatic intervention of the generator, which will be cancelled only when the operator acknowledges the early warning.

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. Switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.
- An "inhibition to power load" has been activated.
- In TEST, P.0222 parameter is set on 0.

The normal AUTOMATIC operation logic (if **GCU** controls **GCB** switches) will be therefore:

1. **Engine stopped and GCB open.** If the automatic intervention of the generator is required, the procedure goes on from step 2.
2. **Engine starting**: wait status before voltage and frequency are within tolerance. Then the procedure goes on from step 3.
3. **GCB open.** If the generator should be stopped (shutdowns, deactivations, discharges, or if automatic intervention is no longer required), the procedure goes on from step 10. If there are requests for "inhibition to power load", the procedure remains at this point. Otherwise, it goes on from:

- Step 6 if there is voltage on the parallel bars of the generators.
- Step 4 if there is no voltage on the parallel bars, and if there are other supplying sets (from information acquired by **PMCB** network).
- It stays at this point if there is no voltage on the parallel bars but there are other supplying generators (from information acquired by the **PMCB** network). It is an anomalous situation, linked to a wiring error. **DST4602x and GC400x** reports this situation by activating W279 early warning ("Inconsistent bar voltages"). If the situation persists for 60 seconds, the anomaly becomes a deactivation (D279), thus causing the shutdown of the generator.

4. **Closing of GCB without synchronization** (three attempts). In case of failure to close, D014 deactivation is activated (**GCB** not closed) and the procedure goes on from step 10 (for **GC500/GC500Plus** it is a shutdown). Otherwise the procedure goes on from step 5.

5. **GCB closed, not in parallel with other generators.** If **GCU** realizes that it is in parallel with other generators, the procedure goes on from step 7. In the case of shutdowns, discharges or deactivations, or if there are requests for "inhibition to power load", the procedure goes on from step 9. If you the automatic triggering of the generator is no longer required, the procedure goes on from step 9.

6. **Closing with synchronization of GCB.** This phase lasts maximum P.0852 seconds. If the switch is closed, the procedure goes on from step 7. If **GCB** isn't closed within the time-limit, **GCU** will activate A271 shutdown (failed parallel on **GCB**) and the procedure goes on from step 10.

7. **GCB closed, in parallel with other generators.** "Active and reactive power distribution" functions have been activated. Each **GCU**, knowing the total active and reactive power of the load and knowing the rated power of all generators, calculates the active and reactive power in percentage entitled to it and then controls the speed and voltage controllers in order to deliver calculated powers. If **GCU** realizes that it is no longer in parallel with other generators, the procedure goes back to step 5. If the generator should to be stopped due to serious problems (shutdowns or deactivations), the procedure goes on from step 9. If the generator should be stopped because discharges or if an "inhibition to power load" have been activated, the procedure goes on from step 8. If you the automatic triggering of the generator is no longer required, the procedure goes on from step 8.

8. **GCB closed, power discharge.** The power of the generator is reduced to 0 kW with a rhythm that can be configured with P.0874 parameter (or P.0875 if there are discharges). This phase lasts until the power of the generator becomes lower than P.0878 threshold or after the time limit configured with P.0879. Then the procedure goes on from step 9. If in the meantime shutdowns or disconnections have been triggered, the procedure goes on directly from step 9. If **GCU** realizes it is no longer in parallel with other generators (or that all the generators are coming out of parallel), the procedure goes on from step 9.

9. **Opening of GCB** (three attempts): if the **GCB** is opened, the procedure goes on from step 3. If **GCB** is not opened:
   - **GC500x**: **GCU** activates A024 shutdown (**GCB** not open) and the procedure goes on from step 10.
   - **DST4602x and GC400x**: **GCU**: triggers W024 early warning ("**GCB** not open"). If P.0243 parameter is set to 1, this early warning becomes a request for automatic intervention (until the operator recognizes the early warning). If there are shutdowns, discharges and deactivations, the procedure goes on from step 10; otherwise it goes on from step 5 or from step 7 (based on the fact that there are other supplying sets).

10. **Engine stop.**

Connection of users to parallel bars.

For this type of system, which does not provide for a parallel with mains, the **GCUs** controlling the generators are also capable of controlling a switch that connects the load to the parallel bar. See description in 2.5.2.

2.5.2 MSB – "Multiple Stand By"

(Emergency multiple system)

See notes in 2.5 that applies to this system, too.

This type of system provides for one or more generators that perform the emergency service to mains. **GCU** provides to start the generator if the mains is "out of tolerance" from the configured time; it stops it if mains is "within tolerance" for the configured time. Parallel with mains is not allowed.

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	**Available**
Synchronization for **MCB**.	Not available.
PMCB communication bus.	**Required.**
Active power distribution.	**Available**
Distribution of reactive power.	**Available**
Protections for the parallel with mains.	Not available.
Power modulation in parallel with mains in BASE LOAD mode.	Not available.
Power modulation in parallel with mains in IMPORT/EXPORT mode.	Not available.
Adjusting of the power factor in parallel with mains.	Not available.
"Transfer to the generators" function.	Not available.
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

GCU prevents the closing of **GCB** (and it forces its opening) if it acknowledges the status of "in parallel with mains" (**MCB** closed and **MGCB** closed or non-existing).

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no "inhibition to starting" is activated and if mains is "out of tolerance". NOTE: the "load management" (see 8.6) can activate the "inhibition to starting" for the generators which should be stopped because not needed to support the load.
- In TEST and in REMOTE START: always ignoring "inhibitions to starting".

Only for DST4602x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence W024 early warning is equivalent to

a request for automatic intervention of the generator, which will be cancelled only when the operator acknowledges the early warning.

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. **GCB** switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.
- An "inhibition to power load" has been activated.
- In TEST, P.0222 parameter is set on 0.
- **MCB** and **MGCB** switches (if any) are both closed.

For the logic of normal operation of the system in AUTO, see the description for MPM system.

Switching of users to mains or to parallel bars.

For MPM and MSB systems (which therefore do not provide for a parallel with mains), **GCUs** are able to control one or two external switches, in order to connect the users to the parallel bars of the generators and/or to mains, without any external device.

The two switches are named:

- GTS (Generators Transfer Switch). It is the switch connecting the load (users) to the parallel bars of the generators. Elsewhere in the manual this switch is called **MGCB**: here a different acronym is used to highlight that **GCU** is able to manage it with very limited logics, which do not provide synchronization and parallel with mains.
- MTS (Mains Transfer Switch). It is the switch connecting the load (users) to mains. Elsewhere in the manual this switch is called **MCB**: here a different acronym is used to highlight that **GCU** is able to manage it with very limited logics, which do not provide synchronization and parallel with mains.

To control these switches the digital outputs of **GCU** are used:

- GTS: use DOF.2091 function (for **DST4602x and GC400x**) or DOF.0031 function (for **GC500x**). **GCU** activates the output to close GTS switch.
- MTS: use DOF.2092 function (for **DST4602x and GC400x**) or DOF.0032 function (for **GC500x**). **GCU** activates the output to open MTS switch (inverted logic).

The function is activated if there is at least an output configured to control GTS. The output associated with MTS is optional.

For the actual control of GTS, it is necessary to wire GTS controls of individual **GCUs** in parallel (so that the switch is closed if at least one **GCU** orders the closing).

For the actual control of MTS, MTS controls of individual **GCUs** should be wired in parallel. NOTE: **GCU activates the output to control the opening of MTS**: connecting them in parallel, it is enough that a single **GCU** controls the opening to open the switch.

The function has the aim to connect users to generators only when the rated power of the generators in parallel is sufficient to supply these users.

To configure this function, **GCU** puts P.0806 parameter at disposal that allows setting (approximately) the power required by the loads. This parameter is automatically shared by all **GCUs** connected to **PMCB** network: it is enough to change it on a **GCU** and it will be automatically transmitted to all the others.

GCU also provides a function for the configuration of the digital inputs (DIF.2181 for **DST4602x and GC400x**, DIF.0070 for **GC500x**), called "immediate supply":

- If the input configured in this way has been activated, each **GCU** controls the switching of the users to the parallel bars as soon as the first generator has closed its **GCB**, therefore ignoring the settings of P.0806.
- If the input has not been activated (or does not exist), each **GCU** controls the switching of the users to the parallel bars when the rating power of all generators with closed **GCB** is higher than P.0806, or when there are no generators available with open **GCB**.

The operational logic is therefore:

1. Let's start from a condition with all stopped generators. GTS switch will be open, while MTS switch (if any) will be closed.
2. Generators start and one of them closes its **GCB** switch. If the digital input has been activated requiring "immediate supply", the procedure goes on from step 4.
3. GCUs go on with the closing of **GCB** switches. Each time a **GCB** switch is closed **GCUs** calculate the rated power of the generators with **GCB** closed and, if greater than P.0806, the procedure goes on from step 4. If all available generators have closed their **GCB** switch, anyway the procedure goes on from step 4.
4. If MTS switch has been configured, **GCUs** will control its opening and wait for the time set with P.0219 parameter (exchange time).
5. **GCUs** control the closing of GTS.

When a generator should come out from the parallel, **GCU** orders:

- The opening of GTS switch.
- If MTS has been configured, it waits P.0219 time and controls the closing of MTS switch.
- Then it opens its own **GCB** switch.

The previous controls have no effect on MTS and GTS switches and if there are other generators that are still supplying: GTS switch will be actually opened only when the last **GCU** will require its opening; MTS switch will be actually closed only when the last **GCU** will require its closing.

Note: failure to open/close MTS and GTS early warnings are not managed.

2.5.3 MSB+MSTP - "Multiple Stand-by" + "Multiple Short Time Parallel"

(Emergency multiple system with fleeting parallel)

See notes in 2.5 that applies to this system, too.

This type of system is very similar to the previous one: it provides one or more generators that perform emergency service to mains. **GCU** provides to start the generator if the mains is “out of tolerance” from the configured time; it stops it if mains is "within tolerance" for the configured time.

Unlike MSB system, however, **GCU** allows the parallel with mains.

Usually, the parallel with mains is temporary (P.0880=0): it is used to avoid a blackout on users during the switching of users from generator to mains (when mains comes back) or from mains to generator (in case of forced intervention in TEST or REMOTE START mode). The maximum duration

of the parallel is 1 second: to use a longer time (but anyway limited), set the needed time in P.0890 parameter and set P.0880 to a value different from zero. Elapsed this time, if the external logic has not opened **MCB** or **MGCB**, **GCU** opens its own **GCB**.

This kind of system also allows the continuative parallel with mains (if P.0880 is different from zero). Usually this function is used to "test" the loaded engine (TEST), without anyway disconnecting users from mains. In this case there isn't a limit to the duration of the parallel. Please refer to the paragraph 3 for all regulations that rules parallel with mains.

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	**Available**
Synchronization for **MCB**.	**Available externally.**
PMCB communication bus.	**Required.**
Active power distribution.	**Available**
Distribution of reactive power.	**Available**
Protections for the parallel with mains.	**Available**
Power modulation in parallel with mains in BASE LOAD mode.	**Available**
Power modulation in parallel with mains in IMPORT/EXPORT mode.	**Available**
Adjusting of the power factor in parallel with mains.	**Available**
"Transfer to the generators" function.	Not available.
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

-

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no “inhibition to starting” is activated and if mains is “out of tolerance”. NOTE: the "load management" (see 8.6) can activate the "inhibition to starting" for the generators that need to be stopped because not needed to support the load (stand-alone supply).
- In TEST and in REMOTE START: always ignoring “inhibitions to starting”.

DST4602x and GC400x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence W024 early warning is equivalent to a request for automatic intervention of the generator, which will be cancelled only when the operator acknowledges the early warning.

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. **GCB** switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.
- An "inhibition to power load" has been activated.

- In TEST, P.0222 parameter is set on 0.

The normal AUTOMATIC operation logic (if **GCU** controls **GCB** switches) will be therefore:

1. **Engine stopped and GCB open.** If the automatic intervention of the generator is required, the procedure goes on from step 2.

2. **Engine starting**: wait status before voltage and frequency are within tolerance. Then the procedure goes on from step 3.

3. **GCB open.** If the generator should be stopped (shutdowns, deactivations, discharges, or if automatic intervention is no longer required), the procedure goes on from step 11. If there are requests for "inhibition to power load", the procedure remains at this point. Otherwise, it goes on from:

    - Step 6 if there is voltage on the parallel bars of the generators.

    - From step 4 if there is no voltage on parallel bars and if **GCU** diagnostics that there are no other supplying generators and that no network is connected to the parallel bars.

    - It stays at this point if there is no voltage on the parallel bars but **GCU** diagnostics that there are other supplying generators or that at least one network is connected to the parallel bars. It is an anomalous situation, linked to a wiring error. **DST4602x and GC400x** reports this situation by activating W279 early warning ("Inconsistent bar voltages"). If the situation persists for 60 seconds, the anomaly becomes a deactivation (D279), thus causing the shutdown of the generator.

4. **Closing of GCB without synchronization** (three attempts). In case of failure to close, D014 deactivation is activated (**GCB** not closed) and the procedure goes on from step 11 (for **GC500x** it is a shutdown). Otherwise the procedure goes on from step 5.

5. **GCB closed, not in parallel with other generators or mains.**
If **GCU** realizes that it in parallel with mains, the procedure goes on from step 8.
If **GCU** realizes that it is in parallel with other generators, the procedure goes on from step 7.
In the case of shutdowns, discharges or deactivations, or if there are requests for "inhibition to power load", the procedure goes on from step 10. If you the automatic triggering of the generator is no longer required, the procedure goes on from step 10.

6. **Closing with synchronization of GCB.** This phase lasts maximum P.0852 seconds. If the switch closes, the procedure goes on from step 8 if the generator is in parallel with mains, otherwise from step 7 (in parallel with other generators). If **GCB** isn't closed within the time-limit, **GCU** will activate A271 shutdown (failed parallel on **GCB**) and the procedure goes on from step 11.

7. **GCB closed, in parallel with other generators.**

    "Active and reactive power distribution" functions have been activated. Each **GCU**, knowing the total active and reactive power of the load and knowing the rated power of all generators, calculates the active and reactive power in percentage entitled to it and then controls the rpm and voltage regulators in order to deliver calculated powers.
    If **GCU** realizes that it in parallel with mains, the procedure goes on from step 8.
    If **GCU** realizes that it in parallel with other generators, the procedure comes back to step 5. If the generator should to be stopped due to serious problems (shutdowns or deactivations), the procedure goes on from step 10. If the generator should be stopped because discharges or if an "inhibition to power load" have been activated, the procedure goes on from step 9. If you the automatic triggering of the generator is no longer required, the procedure goes on from step 9.

8. **GCB closed, in parallel with mains.**

   GCU should calculate the power setpoint for the generator:

   - P.0880 = 0. Continuative parallel with mains is not allowed. Power setpoint is 0 kW.
   - P.0881 = 1 (BASE LOAD). The power setpoint is P.0884 parameter (or a value acquired by the analogue inputs).
   - P.0881 = 2 (IMPORT/EXPORT). **GCU** calculates a power setpoint for the generator, so that power exchanged with the mains reaches the required value (P.0888).
   - P.0881 = 4 (System BASE LOAD). Only for **DST4602x and GC400x**, the power setpoint for the plant is the parameter P.0858 (or a value acquired by the analogue inputs). Each GCU, by knowing the nominal power of all gensets, calculates the related active power in percentage.

   GCU controls the output of the generator to bring it to calculated value.

   If **GCU** you realizes that it is no longer in parallel with mains, the procedure comes back to step 7 if the generator is in parallel with other generators; otherwise it comes back to step 5.

   If the protections for the "parallel with mains" have been activated and **GCB** switch is the interface device (P.0900 = 1), the procedure goes on from step 10.

   If the protections for the "parallel with mains" have been activated and **GCB** switch is the backup device (P.0900= 2), if **MCB** and **MGCB** have not been opened within 0.5 seconds, **GCU** activates A275 shutdown (interface switch not open), and the sequence goes on from step 10.

   If the generator should to be stopped due to serious problems (shutdowns or deactivations), the procedure goes on from step 10. If the generator should be stopped because discharges or if an "inhibition to power load" have been activated, the procedure goes on from step 9. If you the automatic triggering of the generator is no longer required, the procedure goes on from step 9.

9. **GCB closed, power discharge.** The power of the generator is reduced to 0 kW with a rhythm that can be configured with P.0874 parameter (or P.0875 if there are discharges). This phase lasts until the power of the generator becomes lower than P.0878 threshold or after the time limit configured with P.0879. Then the procedure goes on from step 10. If in the meantime shutdowns or disconnections have been triggered, the procedure goes on directly from step 10. If **GCU** realizes that it is no longer in parallel with other generators (or that all the generators are coming out of parallel), the procedure goes on from step 10.

10. **Opening of GCB** (three attempts): if the **GCB** is opened, the procedure goes on from step 3. If **GCB** is the interface switch (P.0900= 1), and the "protections of parallel with mains" have been activated and the generator is in parallel with mains, **GCB** should be opened within 0.5 seconds, otherwise **GCU** activates A275 shutdown (interface switch not open) and the procedure goes on from step 11.

    In the other cases, **GCU** utilizes the normal time-out for the switch. If **GCB** is not opened:

    - **GC500x**: **GCU** activates A024 shutdown (**GCB** not open) and the procedure goes on from step 11.
    - **DST4602x and GC400x**: triggers W024 early warning ("**GCB** not open"). In case of shutdowns, deactivations or discharges, the engine should be stopped and therefore the procedure will go on from step 11. In the other

cases, if **GCU** is configured to keep the generator running, in case of failure to open **GCB** (P.0243= 1), the procedure comes back to step:

- 8 if the generator is in parallel with mains.
- 7 if the generator is in parallel with other generators that are not coming out of parallel.
- 5 in the other cases.

If instead P.0243=0, the process goes on from step 11.

11. **Engine stop.**

2.5.4 MPtM – "Multiple Parallel to Mains"

(Mains parallel multiple system)

See notes in 2.5 that applies to this system, too.

This is a production system "in parallel with mains" only. **GCU** starts the generator when parallel is allowed by the status of the mains (see 3.2.1); it disconnects the generator when "protections for parallel with mains" are activated (see 3); it stops the generator when the status of the mains doesn't authorize parallel consecutively for P.0899 seconds.

The "stand-alone" supply is not allowed: therefore, if some "protections for parallel with mains" are activated, in any case **GCU** open the switch **GCB** , regardless the interface switch should be selected with the P.0900 parameter (see 3). It is preferable to select **GCB** as interface switch (P.0900=1).

Parallel with mains should be continuative, so P.0880 parameter should be set to a value different from zero (otherwise **GCU** activates A273 shutdown "incoherent parameters") and P.0890 parameter (maximum duration of parallel with mains) should be set to zero.

Please refer to the paragraph 3 for all regulations that rules parallel with mains.

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	**Available**
Synchronization for **MCB**.	Not available (stand-alone supply not possible).
PMCB communication bus.	**Required.**
Active power distribution.	Not available.
Distribution of reactive power.	Not available.
Protections for the parallel with mains.	**Available**
Power modulation in parallel with mains in BASE LOAD mode.	**Available**
Power modulation in parallel with mains in IMPORT/EXPORT mode.	**Available**
Adjusting of the power factor in parallel with mains.	**Available**
"Transfer to the generators" function.	Not available.
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

The switch can be closed only if **MCB** is closed (if it exists, also **MGCB** should be closed) and if the status of mains authorizes the parallel. It can therefore be closed only with synchronization.

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no "inhibition to starting" is active and if the status of the mains authorizes the parallel with mains.
- In TEST and in REMOTE START: always ignoring “inhibitions to starting”.

DST4602x and GC400x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence W024 early warning is equivalent to a request for automatic intervention of the generator, which will be cancelled only when the operator acknowledges the early warning.

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. **GCB** switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.
- The protections for the "parallel with mains" have been triggered.
- The status of the mains does not authorize parallel.
- An "inhibition to power load" has been activated.
- In TEST, P.0222 parameter is set on 0.

The normal AUTOMATIC operation logic (if **GCU** controls **GCB** switches) will be therefore:

1. **Engine stopped and GCB open.** If the automatic intervention of the generator is required, the procedure goes on from step 2.
2. **Engine starting**: wait status before voltage and frequency are within tolerance. Then the procedure goes on from step 3.
3. **GCB open.** If the generator should be stopped (shutdowns, deactivations, discharges, or if automatic intervention is no longer required), the procedure goes on from step 8. If there are requests for "inhibition to power load", the procedure remains at this point. If mains does not allow parallel, the procedure stays at this step. Otherwise, it goes on from step 4.
4. **Closing with synchronization of GCB.** This phase lasts maximum P.0852 seconds. If the switch is closed, the procedure goes on from step 5. If **GCB** isn't closed within the time-limit, **GCU** will activate A271 shutdown (failed parallel on **GCB**) and the procedure goes on from step 8.
5. **GCB closed, in parallel with mains.**

   GCU should calculate the power setpoint for the generator:

   - P.0881 = 1 (BASE LOAD). The power setpoint is P.0884 parameter (or a value acquired by the analogue inputs).

- P.0881 = 2 (IMPORT/EXPORT). **GCU** calculates a power setpoint for the generator, so that power exchanged with the mains reaches the required value (P.0888).

- P.0881 = 4 (System BASE LOAD). Only for **DST4602x and GC400x**, the power setpoint for the plant is the parameter P.0858 (or a value acquired by the analogue inputs). Each GCU, by knowing the nominal power of all gensets, calculates the related active power in percentage.

GCU controls the output of the generator to bring it to calculated value.

If **GCU** realizes that it is no longer in parallel with mains, the procedure goes on from step 7.

If the protections for the "parallel with the grid" have been triggered, whatever the interface switch is (P.0900), the procedure goes on from step 7.

If the generator should to be stopped due to serious problems (shutdowns or deactivations), the procedure goes on from step 7. If the generator should be stopped because discharges or if an "inhibition to power load" have been activated, the procedure goes on from step 6. If you the automatic triggering of the generator is no longer required, the procedure goes on from step 6.

6. **GCB closed, power discharge.** The power of the generator is reduced to 0 kW with a rhythm that can be configured with P.0874 parameter (or P.0875 if there are discharges). This phase lasts until the power of the generator becomes lower than P.0878 threshold or after the time limit configured with P.0879. Then the procedure goes on from step 7. If in the meantime shutdowns or disconnections have been triggered, the procedure goes on directly from step 7. If **GCU** realizes that it is no longer in parallel with mains or if the protections for the "parallel with mains" have been triggered, the procedure goes on from step 7.

7. **Opening of GCB** (three attempts): if the **GCB** is opened, the procedure goes on from step 3.

   If **GCB** is the interface switch (P.0900= 1), and the protections for the "parallel with mains" have been triggered and the generator is in parallel with mains, **GCB** should be opened within 0.5 seconds; otherwise **GCU** activates A275 shutdown (interface switch not open), and the procedure goes on from step 8.

   In the other cases, **GCU** utilizes the normal time-out for the switch. If **GCB** is not opened:

   - **GC500x**: **GCU** activates A024 shutdown (**GCB** not open) and the procedure goes on from step 8.

   - **DST4602x and GC400x**: triggers W024 early warning ("**GCB** not open"). In case of shutdowns, deactivations or discharges, the engine should be stopped and therefore the procedure will go on from step 8. In the other cases, if **GCU** is configured to keep the generator running, in case of failure to open **GCB** (P.0243= 1), the procedure comes back to step 5. If instead P.0243=0, the process goes on from step 8.

8. **Engine stop.**

2.5.5 MPtM + MSB – "Multiple Parallel to Mains" + "Multiple Stand By"

(Mains parallel multiple system with possibility to operate stand alone as well)

See notes in 2.5 that applies to this system, too.

In this type of system, the generator can deliver both "stand alone" and in "parallel with mains". It is very similar to system MSB + MSTP. The differences with reference to it are:

- This system is not an emergency system; then the request for automatic triggering of the generator is not linked to the status of the mains.
- The uninterrupted parallel with mains (P.0880 > 0) should be allowed.

As the stand-alone supply is allowed, it is preferable (but not mandatory) to select **MCB** as interface switch (P.0900= 2).

Please refer to the paragraph 3 for all regulations that rules parallel with mains.

Parallel functions:

Function.	**Availability**
Synchronization for **GCB**.	**Available**
Synchronization for **MCB**.	**Available externally.**
PMCB communication bus.	**Required.**
Active power distribution.	**Available**
Distribution of reactive power.	**Available**
Protections for the parallel with mains.	**Available**
Power modulation in parallel with mains in BASE LOAD mode.	**Available**
Power modulation in parallel with mains in IMPORT/EXPORT mode.	**Available**
Adjusting of the power factor in parallel with mains.	**Available**
"Transfer to the generators" function.	Not available.
DROOP mode.	**Available**

Further restrictions for the closing of GCB.

-

Automatic sequence.

The automatic intervention of the generator is required under the following conditions:

- In AUTO: if no "starting inhibition" has been activated. NOTE: the "load management" (see 8.6) can activate the "inhibition to starting" for the generators which should be stopped because not needed to support the load (stand-alone supply).
- In TEST and in REMOTE START: always ignoring “inhibitions to starting”.

DST4602x and GC400x: by setting P.0243 parameter to "1", **GCU** is configured to keep the generator supplying in the event of failure to open **GCB** switch (if there are no shutdowns, deactivations and discharges). In this case, the presence W024 early warning is equivalent to a request for automatic intervention of the generator, which will be cancelled only when the operator acknowledges the early warning.

With the engine in action, **GCU** has to decide whether closing or not **GCB** switch. **GCB** switch should always be closed, save for the following cases:

- Shutdowns, disconnection or discharges have been activated.
- The shutdown of the generator is required.

- An "inhibition to power load" has been activated.
- In TEST, P.0222 parameter is set on 0.

For the logic of normal operation of the system in AUTO, see the description for MSB + MSTP system.

3. Use of mains/bars sensor for the parallel with mains

GCU should know the status of the power mains for two reasons:

- In systems that do "emergency" service in order to decide whether to start/stop the generator automatically.
- In systems that manage the supply in "parallel with mains", to allow or not the parallel.

Refer to **GCU** technical manual regarding the management of the mains for the emergency service (configuration and management logics).

This chapter instead describes the configuration and logics applicable to the power mains for the "parallel with mains".

Basically, **GCU** should acquire two pieces of information:

- If mains voltage and frequency have values that allow the generator to start the parallel.
- Once in parallel with the mains, special techniques are needed to recognize fast any anomalies present on the mains, in order to disconnect the generator from the mains. The main problem is that if the mains is not present while the generator is in parallel with it, the generator will no longer be synchronized with the mains when it is present again: it is therefore necessary to disconnect the generator from the mains before this happens. The combination of these techniques is identified as "Protection for Parallel with Mains" (PPR in Italian).

For these controls, **GCU** can use its mains/bars sensor or an external sensor. In some countries, the device which should manage the protections for the "parallel with mains" needs to be homologated, then it is often necessary to use an external device.

3.1 Use of the external sensor

The sensor should be connected to a digital input of GCU (function DIF.3103 for **DST4602x and GC400x**, DIF.0039 for **GC500x**).

Warning: do not use DIF.3101 (for **DST4602x and GC400x**) or DIF.0060 (for **GC500x**) to configure the digital input. They are dedicated to the management of the mains for emergency service purpose.

When no protection for the "parallel with mains" is active, the input should be activated (mains ok). Therefore **GCU** will allow the parallel with mains only if the input is active. It will also open a switch (called the interface switch) to isolate the generator from the mains as soon as this input becomes "inactive".

The change of the digital input is recorded in the records file:

Event codes	Description	Note
EVT.1098	Triggered protection	
EVT.1158	Protection reset	**DST4602x and GC400x**.

Note: in case of using an external sensor, the internal sensor is ignored; the possible mains status sent to the MC100 controller on Can Bus PMCB is ignored too.

See also the notes in 3.2.4.

3.2 Use of the internal sensor

GCU can use its mains/bars sensor to acquire mains measurements. It is first of all necessary to configure this sensor by using these parameters:

Parameter	Description	Unit	Note
P.0126	Use of mains/bars sensor.	-	Set to “1”
P.0119	Number of phases.	-	
P.0105	Rated frequency	Hz	

P.0116	Rated voltage	Vac	
P.0117	Primary of voltammetric transformers.	Vac	
P.0118	Secondary of voltammetric transformers.	Vac	
P.0129	The neutral is connected.	-	**DST4602x and GC400x**.

See **GCU** technical manual for connections of mains lines.

After performing the connections and the configuration with the parameters indicated above, **GCU** is able to measure mains frequency and voltage. It is now necessary to configure thresholds and delays relating to the "parallel with mains".

Note: in case of using an internal sensor, the possible mains status sent to the MC100 controller on Can Bus PMCB is ignored.

3.2.1 Authorization to parallel.

GCU allows the supply in "parallel with the mains" if no protection for the "parallel with the mains" has been triggered.

Everything that follows in this section is valid **for DST4602x and GC400x** (but in the future also for all **GCUs**).

DST4602x and GC400x device has moreover implemented the latest European standards for parallel with mains. In short, the new regulations require that the generator can be in parallel with mains even if the voltage and frequency of mains diverge significantly from rated values: once, however, that the parallel has been discontinued, it is necessary that mains voltage and the frequency come back close to rated values to enable the new parallel.

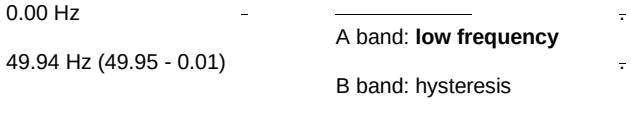
This configuration, on **DST4602x and GC400x**, is performed with the following parameters:

Parameter	Description	Unit	Note	Valid values
P.0903	Delay of parallel with mains from mains within tolerance.	s		0.0...3200.0
P.0905	Minimum mains frequency to consent parallel.	% P.0105		80.00...120.00%
P.0906	Maximum mains frequency to consent parallel.	% P.0105		80.00...120.00%
P.0909	Minimum mains voltage to consent parallel.	% P.0116		80.0...120.0%
P.0910	Maximum mains voltage to consent parallel.	% P.0116		80.0...120.0%
P.0911	Hysteresis on voltages for "mains failure" protections.	% P.0116		0.1...10.0%

The Italian legislation specifies that mains frequency should be between 49.95 and 50.05Hz, and that voltage should be between 85% and 110% of rated voltage.

In short **GCU** allows parallel with mains if mains frequency is between the thresholds set in P.0905 and P.0906, and if voltages are between the thresholds set in P.0909 and P.0910. The previous conditions shall continue consecutively for the time set in parameter P.0903. Warning: if the generator is already running in parallel to mains, it is not disconnected from the mains based on these thresholds, but only if the protections for the "parallel with the mains" have been triggered.

The verification of frequency is performed with a 0.01 Hz hysteresis on the thresholds. Assuming to operate with a rated frequency of 50 Hz and with the parameters configured for the Italian legislation, **GCU** will use the following ranges:



49.96 Hz (49.95 + 0.01)	C band: **correct frequency**
50.04 Hz (50.05 - 0.01)	D band: hysteresis
50.06 Hz (50.05 + 0.01)	E band: **high frequency**
xxx	

To allow parallel with the mains, therefore, the frequency should be included at least one time in C range (between 49.96 and 50.04 Hz) and never get out from ranges B, C and D. As soon as it no more included in these ranges, the time count configured in P.0903 restarts from zero.

The verification of voltages is performed with a hysteresis configurable with P.0911 parameter. See next paragraph for notes on the management of hysteresis. Assuming to operate with a rated voltage of 400Vac and with the parameters configured for the Italian legislation, **GCU** will use the following ranges:

0.00 Vac	A band: **low voltage**
340 Vac	B band: hysteresis
348 Vac (340 + 8)	C band: **correct voltage**
432 Vac (440 – 8)	D band: hysteresis
440 Vac	E band: **high voltage**
xxx	

To allow parallel with the mains, therefore, voltages should be included at least one time in C range (included between 348 e 432 Vac) and never get out from ranges B, C and D. As soon as it is no more included in these ranges, the time count configured in P.0903 restarts from zero.

DST4602x and GC400x provides DOF.3037 function ("Consent to parallel with mains") for the configuration of digital outputs. **GCU** activates this output when mains voltage and frequency are within the thresholds described above for the time configured in P.0903.

3.2.2 Management of hysteresis.

GCU uses the hysteresis on all thresholds. For some thresholds, the hysteresis is configurable, for other thresholds it is fixed.

3.2.2.1 Hysteresis on voltage thresholds.

Parameter	Description	Note	Unit	Valid values
P.0911	Hysteresis on the voltages for the protections of "parallel with mains".		%	0.1...10.0
P.0908.15	Applies hysteresis for voltage thresholds.	**DST4602x and GC400x**.	-	0/1

The two parameters are used for the following protections:

- "27 U<<".
- "27 U<" (**DST4602x and GC400x**).
- "27 T" (**DST4602x and GC400x**).
- "27 Q→ & U<" (**DST4602x and GC400x**).
- "59 U>>".
- "59 U>" (**DST4602x and GC400x**).

P.0908.15 parameter is available **DST4602x and GC400x**. **GC500x** behave as if this parameter were set to 0.

GCU can use two different ways to manage voltage hysteresis:

- P.0908.15 = "0". In this mode, P.0911 is managed as a percentage of rated voltage (P.0116). This is the only mode available for **GC500x**.

$$Soglia\ di\ ripristino\ (27) = \frac{(Soglia\ di\ scatto + P.0911) * P.0116}{100}$$

$$Soglia\ di\ ripristino\ (59) = \frac{(Soglia\ di\ scatto - P.0911) * P.0116}{100}$$

Example for 27 protections:

P.0116 = 15000 Vac

P.0911 = 2,0 %

Configured threshold = 80.0%

Intervention threshold: **12000** Vac

Reset threshold: **12300** Vac

- P.0908.15 = "1". In this mode, P.0911 is managed as a percentage of the threshold. This mode is not available for **GC500x**.

$$Soglia\ di\ ripristino\ (27) = \frac{\left(Soglia\ di\ scatto + \left(\frac{Soglia\ di\ scatto * P.0911}{100}\right)\right) * P.0116}{100}$$

$$Soglia\ di\ ripristino\ (59) = \frac{\left(Soglia\ di\ scatto - \left(\frac{Soglia\ di\ scatto * P.0911}{100}\right)\right) * P.0116}{100}$$

Example for 27 protections:

P.0116 = 15000 Vac

P.0911 = 2,0 %

Configured threshold = 80.0%

Intervention threshold: **12000** Vac

Reset threshold: **12240** Vac

3.2.2.2 Hysteresis on frequency thresholds.

Parameter	Description	Unit	Note	Valid values
P.0921	Hysteresis on frequency for the protections for the "parallel with mains".	%		0.1...10.0
P.0908.16	Applies hysteresis for frequency on thresholds.	-	**DST4602x and GC400x**.	0/1

The two parameters are used for the following protections:

- "81 f<<".
- "81 f <" (**DST4602x and GC400x**).
- "81 f >>".
- "81 f >" (**DST4602x and GC400x**).

P.0908.16 parameter is available only for **DST4602x and GC400x**. **GC500x** behave as if this parameter were set to 0.

GCU can use two different ways to manage frequency hysteresis:

- P.0908.16 = "0". In this mode, P.0921 is managed as a percentage of rated frequency (P.0105). This is the only mode available for **GC500x**.

$$Soglia\ di\ ripristino\ (81 \ll) = \frac{(Soglia\ di\ scatto + P.0921) * P.0105}{100}$$

$$Soglia\ di\ ripristino\ (81 \gg) = \frac{(Soglia\ di\ scatto - P.0921) * P.0105}{100}$$

Example for 81 < protection:

P.0105 = 50 Hz.

P.0921 = 1,0 %

Configured threshold = 95.0%

Intervention threshold: **47.50** Hz

Reset threshold: **48.00** Hz

- P.0908.16 = "1". In this mode, P.0921 is managed as a percentage of the threshold. This mode is not available for **GC500x**.

$$Soglia\ di\ ripristino\ (81 \ll) = \frac{\left(Soglia\ di\ scatto + \left(\frac{Soglia\ di\ scatto * P.0921}{100}\right)\right) * P.0105}{100}$$

$$Soglia\ di\ ripristino\ (81 \gg) = \frac{\left(Soglia\ di\ scatto - \left(\frac{Soglia\ di\ scatto * P.0921}{100}\right)\right) * P.0105}{100}$$

Example for 81< protections:

P.0105 = 50 Hz.

P.0921 = 1,0 %

Configured threshold = 95.0%

Intervention threshold: **47,500** Hz

Reset threshold: **47,975** Hz

3.2.2.3 Hysteresis on power thresholds.

The hysteresis for the threshold on "positive sequence" current I1 (or I+) (used for "27 Q→ & U <" protection) is set at 5.0%: the reset threshold for this protection is therefore 95% of the intervention threshold.

3.2.2.4 Hysteresis on reactive power thresholds.

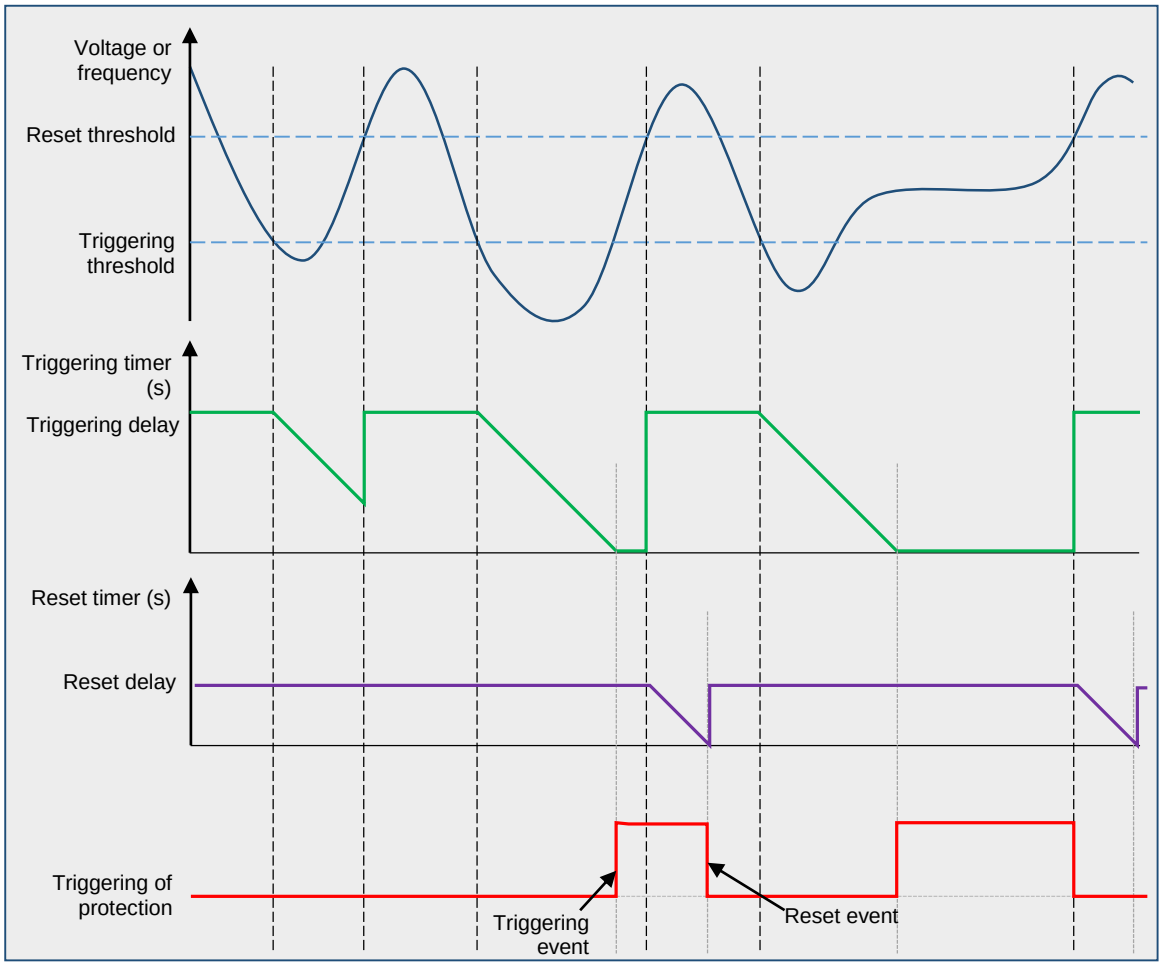
The hysteresis for reactive power "positive sequence" Q1 (or Q +) threshold (used for "27 Q→ & U <" protection) is set at 5.0%, the reset threshold for this protection is therefore 95% of the intervention threshold.

3.2.3 Operational diagrams

3.2.3.1 Operational diagram for low voltage/frequency thresholds

The diagram is applied to the protections:

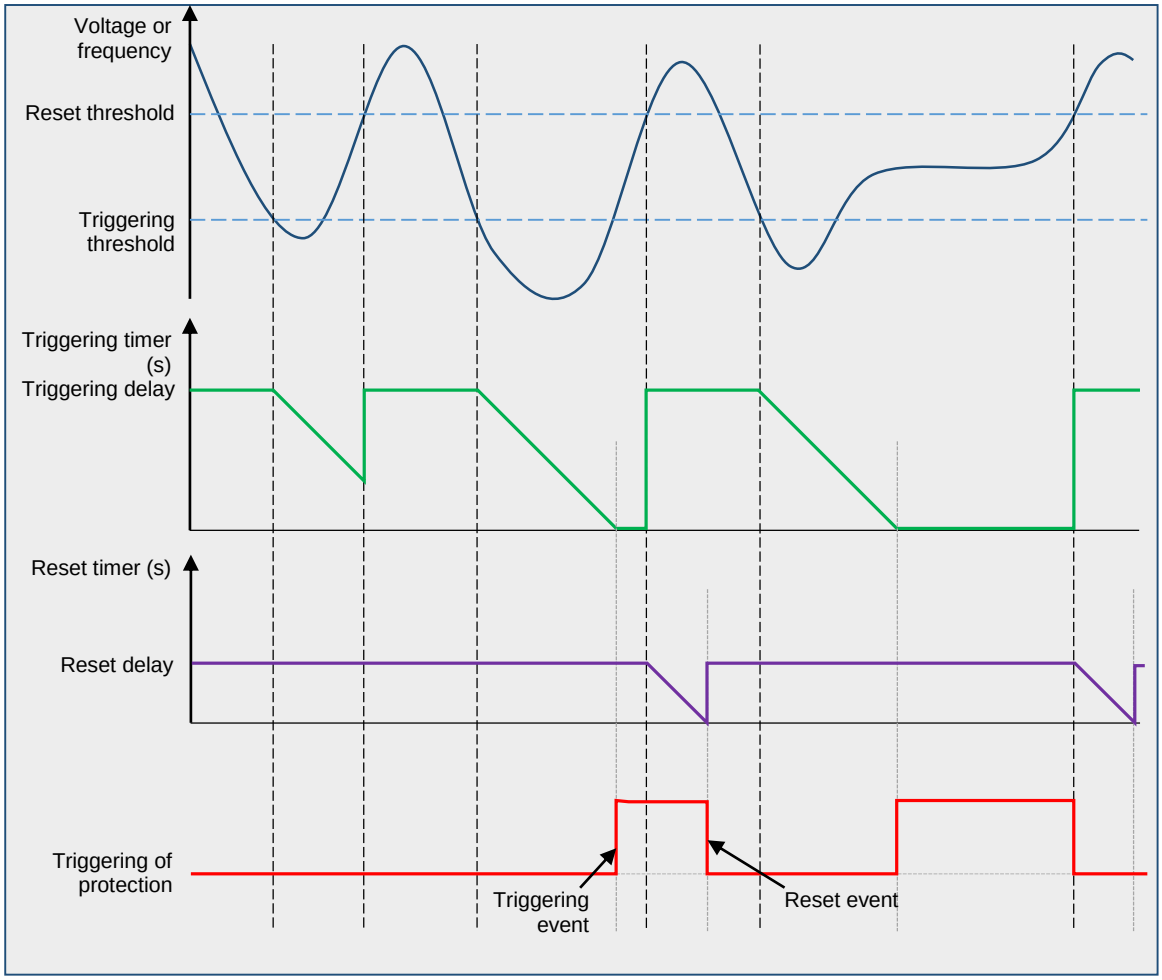
- “27 U<<”.
- “27 U<” (**DST4602x and GC400x**).
- “81 f<<”.
- “81 f<” (**DST4602x and GC400x**).



3.2.3.2 Operational diagram for high voltage/high frequency thresholds.

The diagram is applied to the protections:

- “59 U>>”.
- “59 U>” (**DST4602x and GC400x**).
- “81 f>>”.
- “81 f>” (**DST4602x and GC400x**).



3.2.4 Common to all the protections for the "parallel with mains".

The information contained in this chapter refers to all protections for the "parallel with mains"; they will not be described again in the chapters on each single protections.

3.2.4.1 Events archive

When a protection for the "parallel with mains" is triggered, **GCU** registers the related event in the record file. **DST4602x and GC400x** also records the reset event for each individual protection. All **GCUs** anyway record "EVT.1099" event that is not linked to a specific protection: it is recorded when the latest triggered protection is reset (so when there are more active protections for the "parallel with mains").

3.2.4.2 Digital outputs

It is possible to configure an output of **GCU** to report the overall status of protections for the "parallel with mains" (DOF.3034 for **DST4602x and GC400x**, DOF.0040 for **GC500x**). The output configured in this way is:

- Immediately **disabled when a** protection is triggered.
- Immediately **activated when all** protections have been re-set. NOTE: with P.0901 parameter it is possible to configure the minimum activation time of this output (even if the failure of the mains lasts less than P.0901 seconds, the output will be activated for this time).

It is possible to use this output to open any switches.

It is also possible to configure an output with DOF.0103 function (AND/OR logics) with ST.052 status: the **output is activated if at least one** protection for the parallel with mains has been activated, if all protections for the parallel with mains are reset, it will **be deactivated**.

3.2.5 "27 U<<" protection – Minimum voltage

3.2.5.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0908.01	Linked/phase voltages	-	**Only for DST4602x**.	0/1
P.0912	**Triggering threshold**	% P.0116		10.0...100.0
P.0913	**Triggering delay**	s		0.00...60.00

Event codes	Description	Note
EVT.1091	Triggered protection	
EVT.1151	Protection reset	**Only for DST4602x**.

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.053: triggered protection.	

P.0908.01 parameter, available only on **DST4602x and GC400x**, allows deciding if the protection works on mains linked voltages (0) or on phase voltages (1). For **GC500x**: the protection always acts on linked voltages.

The protection can be disabled by putting the **release delay** at "0.00".

There are no parameters to configure the **reset threshold**.

There are no parameters to configure the **reset threshold.** It is calculated from the triggering threshold and from hysteresis (see 3.2.2.1). There are no parameters to configure **reset delay.** The delay is 700 ms on **DST4602x and GC400x**, 0 ms on **GC500x**.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.053 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.5.2 Description of operations

See diagram 3.2.3.1.

See the common notes in 3.2.4.

The protection is triggered when at least one mains voltage is below the **triggering threshold** consecutively for the **triggering delay**.

The protection is restored when all mains voltages are above **reset threshold** consecutively for the **reset delay**.

3.2.6 "27 U<<" protection – Minimum voltage

This protection is available **only for DST4602**.

3.2.6.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0908.02	Linked/phase voltages	-	**Only for DST4602x**.	0/1

P.0916	**Triggering threshold**	% P.0116	**Only for DST4602x**.	10.0...100.0
P.0917	**Triggering delay**	s	**Only for DST4602x**.	0.0..3200.0

Event codes	Description	Note
EVT.1100	Triggered protection	**Only for DST4602x**.
EVT.1160	Protection reset	**Only for DST4602x**.

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.059: triggered protection.	**Only for DST4602x**.

P.0908.02 parameter allows deciding whether the protection works on mains linked voltages (0) or on phase voltages (1).

The protection can be disabled by setting the **triggering delay** to "0.0".

There are no parameters to configure the **reset threshold.** It is calculated from the triggering threshold and from hysteresis (see 3.2.2.1). There are no parameters to configure **reset delay.** The delay is 700 ms on **DST4602x and GC400x**, 0 ms on **GC500x**.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.059 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.6.2 Description of operations

See diagram 3.2.3.1.

See the common notes in 3.2.4.

The protection is triggered when at least one mains voltage is below the **triggering threshold** consecutively for the **triggering delay**.

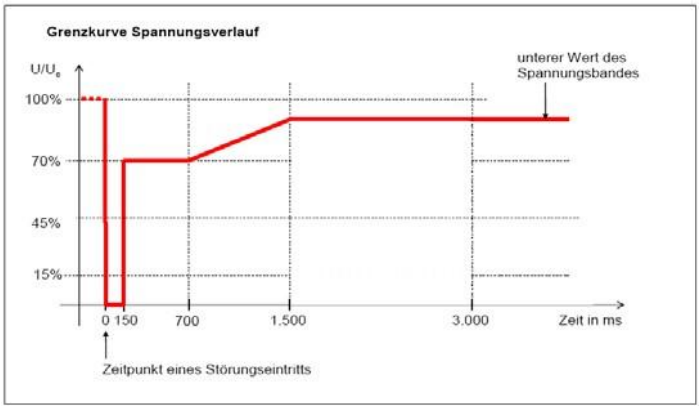
The protection is restored when all mains voltages are above **reset threshold** consecutively for the **reset delay**.

3.2.7 Protection "T- 27" - time-dependent low voltage

This protection is available **for DST4602x and GC400x**.

3.2.7.1 Overview

The latest European directives on the theme of production of power in parallel with mains require production systems connected to medium-voltage mains to participate to sustaining of mains voltages in the event of failure of the mains itself. In particular, the Directive establishes that these systems should not be disconnected from the mains in case of failure on the mains itself, according to the following diagram (taken from the German standard):



The system should never be disconnected from the power mains if all mains voltages are above the red line in the image above. Actually:

- The protection should not intervene for any size of voltage drops (even at 0 Vac) if the failure lasts less than 150 ms.
- The protection should intervene in 150 ms if at least one mains voltage drops below 70% of rated voltage.
- The intervention delay should be calculated dynamically by following the red line (between 700 ms and 1500 ms) if the lowest of mains voltages has a value included between 70% and 90% of rated voltage.
- The protection should not intervene if all mains voltages are above 90% of rated voltage.

Actually, there are addendums to the standard that consider the special needs of generators: the standard indicates that, in this case, the system can be immediately disconnected from the mains if at least one mains voltage drops below 30% of rated one. This condition can be met by using "27 U<<" protection along with it.

3.2.7.2 Configuration

Parameter	Description	Unit	Note	Valid values
P.0908.03	Linked/phase voltages	-	**DST4602x and GC400x**	0/1
P.1211	Enabling of protection	-	**DST4602x and GC400x**	0/1
P.1212	**Triggering threshold #1**	% P.0116	**DST4602x and GC400x**	0.0…100.0
P.1213	**Triggering delay #1**	s	**DST4602x and GC400x**	0.00…60.00
P.1214	**Triggering threshold #2**	% P.0116	**DST4602x and GC400x**	0.0…100.0
P.1215	**Triggering delay #2**	s	**DST4602x and GC400x**	0.00…60.00
P.1216	**Triggering threshold #3**	% P.0116	**DST4602x and GC400x**	0.0…100.0
P.1217	**Triggering delay #3**	s	**DST4602x and GC400x**	0.00…60.00
P.1218	**Reset delay**	s	**DST4602x and GC400x**	0.0…3200.0

Event code	Description	Note
EVT.1104	Triggered protection	**DST4602x and GC400x**

EVT.1164	Protection reset	**DST4602x and GC400x**

Digital input functions	Description	Note
DIF.2712	Enables protection	**DST4602x and GC400x**

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.063: triggered protection.	**DST4602x and GC400x**

The protection is enabled if:

- Parameter P.1211 is set to 1 (to disable it, set it to 0).
- If there is a digital input configured with DIF.2712 function, this should be active.

There are no parameters to configure the **reset thresholds.** They are calculated from the triggering thresholds and from hysteresis (see 3.2.2.1).

P.0908.03 parameter allows deciding whether the protection works on mains linked voltages (0) or on phase voltages (1).

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.063 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.7.3 Description of operations

See diagram 3.2.3.1.

See the common notes in 3.2.4.

The protection operates on the lowest of mains voltages.

The operator defines the "triggering line" (see figure above) by setting the three **triggering thresholds** and the three **triggering delays**:

- **Triggering threshold #1**. The protection is triggered if the lowest of mains voltages falls below this threshold (and remains below the applicable reset threshold) constantly for the **triggering time #1** . Note: for applications in Germany, set the **triggering threshold # 1** to "0.0" to disable it (not required).
- **Triggering threshold #2**. The protection is triggered if the lowest of mains voltages falls below this threshold (and remains below the applicable reset threshold) constantly for the triggering time #1 (note: **triggering time #1**, not triggering time #2). In this case, **GCU** ensures that the fault had a minimum duration equal to **triggering time # 1**, possibly by adding a slight delay in the intervention of the protection. This to comply with German specifications: do not disconnect the generator from the mains for any fault on the mains lasting less than 150 ms.
- **Triggering threshold #3**. The protection is triggered if the lowest of mains voltages falls below this threshold (but not below threshold #2) (and remains below the applicable reset threshold) constantly for the triggering time. In this case, triggering time is dynamically calculated with a linear interpolation between the "triggering time # 2" and "triggering time # 3" parameters.

If the lowest of mains voltages is higher than the **triggering threshold #3**, the protection won't be activated.

The protection is restored when the lowest of mains voltage is above the **reset threshold #3** continuously **for reset time**.

3.2.8 "27 Q→ & U<" protection – Minimum voltage & directional reactive

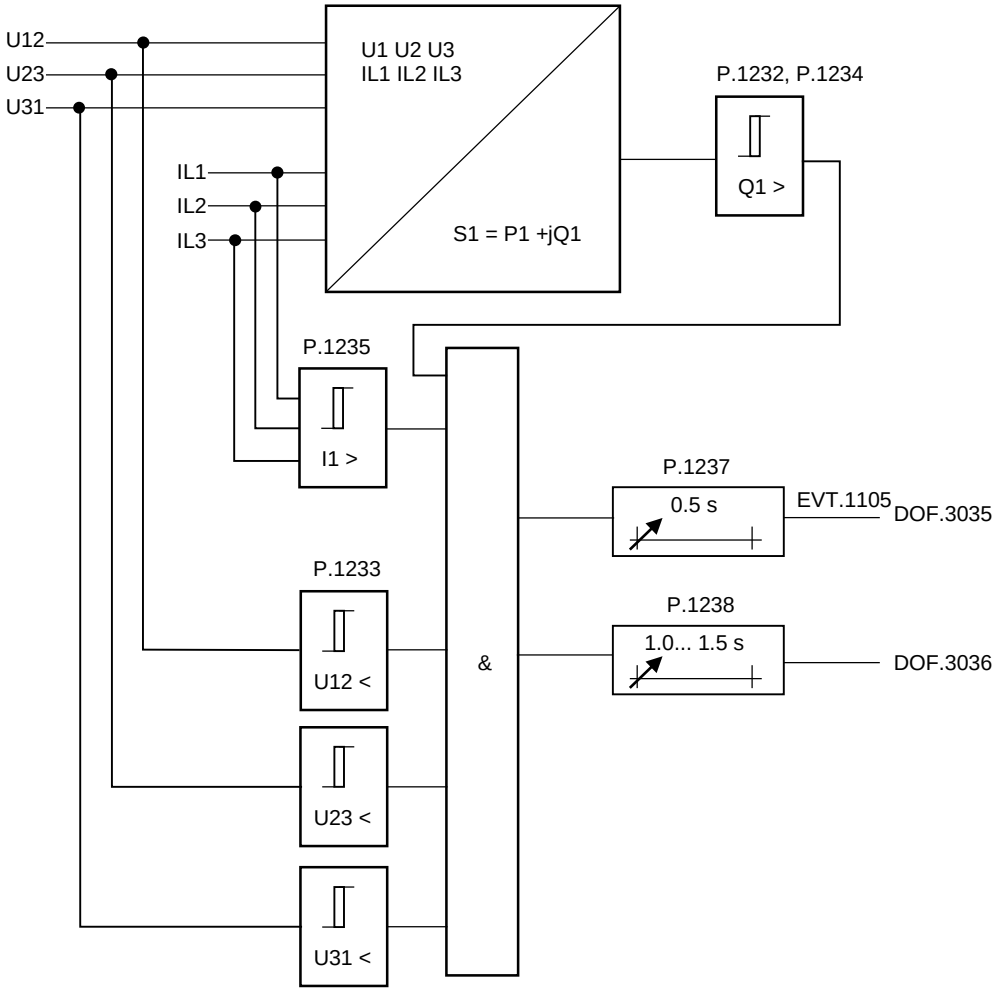
3.2.8.1 Overview

This protection is available **for DST4602x and GC400x**.

This protection is required by the German standards to allow the connection of electrical power production systems to medium-voltage mains.

The standard indicates that these systems should support mains voltage in the event of mains failures, without being disconnected from the mains itself but by injecting reactive power into the mains to try to support voltages. But, if during the fault, a reactive power flow towards the system is detected, then the system itself should be disconnected from the mains (because it is not supporting the mains, but rather helps to lower its voltages).

To recognize the condition in which the reactive power flows from the mains to the system, the standard orders to use the positive sequence measurement of current "I1" (or "I+") and the measurement of positive sequence reactive power "Q1" (or "Q+"). **GCU does not use the angle of Q1vector for this protection (not mandatory).**



GCU uses the following formula to calculate Q1 positive sequence reactive power (where V1 and I1 are positive sequence voltage and current):

$$Q_1 = 3 * \frac{|V_1|}{\sqrt{2}} * \frac{|I_1|}{\sqrt{2}} * \sin\varphi$$

$$\varphi = \angle V_1 - \angle I_1$$

3.2.8.2 Configuration

Parameter	Description	Unit	Note	Valid values
P.0908.04	Linked/phase voltages	-	**DST4602x and GC400x**	0/1
P.1231	Enabling of protection	-	**DST4602x and GC400x**	0/1
P.1232	Reactive power sign.	-	**DST4602x and GC400x**	0/1
P.1233	**Voltage triggering threshold.**	% P.0116	**DST4602x and GC400x**	0.0…100.0
P.1234	**Reactive power triggering threshold.**	% Qn	**DST4602x and GC400x**	0.0…100.0
P.1235	**Current triggering threshold.**	% In	**DST4602x and GC400x**	0.0…100.0
P.1237	**Triggering delay # 1.**	s	**DST4602x and GC400x**	0.00…60.00
P.1238	**Triggering delay # 2.**	s	**DST4602x and GC400x**	0.00…60.00
P.1239	Reset delay	s	**DST4602x and GC400x**	0.0…3200.0

Event code	Description	Note
EVT.1105	Triggered protection	**DST4602x and GC400x**
EVT.1165	Protection reset	**DST4602x and GC400x**

Digital input functions	Description	Note
DIF.2713	Enables protection	**DST4602x and GC400x**

Digital Output functions	Description	Note
DOF.3035	Triggered protection: first control.	**DST4602x and GC400x**
DOF.3036	Triggered protection: second control.	**DST4602x and GC400x**
DOF.0103	AND/OR logic, with status ST.051: triggered protection.	**DST4602x and GC400x**

The protection is enabled if:

- Parameter P.1231 is set to 1 (to disable it, set it to 0).
- If there is a digital input configured with DIF.2713 function, this should be active.

There are no parameters to configure the **reset thresholds.** They are calculated from triggering thresholds and from hysteresis (see 3.2.2.1 and following paragraphs). See **GCU** technical manual for the determination of rated reactive power and rated current.

P.0908.04 parameter allows deciding whether the protection works on mains linked voltages (0) or on phase voltages (1).

With P.1232 parameter it is possible to select the sign that the reactive power should have (as measured by **GCU**) for the triggering of the protection: negative (0) or positive (1). As a rule it should be negative.

Note: when the protection is triggered, the output configured with AND/OR logics (status ST.051) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2 and with reference to the outputs configured with DOF.3035 and DOF.3036 functions. It is preferable to use those outputs to control the opening of the switches.

3.2.8.3 Description of operations

See the common notes in 3.2.4.

The protection intervenes if all the following conditions are met:

- All mains voltages become lower of the triggering threshold (and remain below the reset threshold).
- I1 current becomes higher than the triggering threshold (and remains above the reset threshold).
- Q1 reactive power has the sign selected with P.1232) and becomes bigger (in absolute terms) than the triggering threshold (and remains above the reset threshold).

If the above conditions for the **triggering delay # 1** persist, the protection is triggered and **GCU** activates the output configured with DOF.3035 function.

If the previous conditions persist for the **triggering delay #2** as well, **GCU** will activate also the output configured with DOF.3036 function. **NOTE: the protection does not verifies switches feedbacks; the second output is anyway activated if the fault on the mains lasts more than this time. If the first triggering of the protection causes the immediate disconnection from the mains, actually there are no conditions for the second triggering.**

The protection is reset if all the following conditions are continuously monitored **for re-set delay**:

- All mains voltages are above the reset threshold.
- I1 current is below the reset threshold.
- Q1 active power is below the reset threshold (or has a different sign than configured in P.1232).

3.2.9 "59 U>>" protection – Maximum voltage

3.2.9.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0908.05	Linked/phase voltages	-	**DST4602x and GC400x**	0/1
P.0914	**Triggering threshold**	% P.0116		60.0...150.0
P.0915	**Triggering delay**	s		0.00...60.00

Event codes	Description	Note
EVT.1092	Triggered protection	
EVT.1152	Protection reset	**DST4602x and GC400x**

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.054: triggered protection.	

P.0908.05 parameter, available only on **DST4602x and GC400x**, allows deciding if the protection works on mains linked voltages (0) or on phase voltages (1). For **GC500x**: the protection always acts on linked voltages.

There are no parameters to configure the **reset threshold**.

There are no parameters to configure the **reset threshold.** It is calculated from the triggering threshold and from hysteresis (see 3.2.2.1). There are no parameters to configure **reset delay.** The delay is 700 ms on **DST4602x and GC400x**, 0 ms on **GC500x**.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.054 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.9.2 Description of operations

See diagram 3.2.3.2.

See the common notes in 3.2.4.

The protection is triggered when at least one mains voltage is above the **triggering threshold** consecutively for the **triggering delay**.

The protection is restored when all mains voltages are below **reset threshold** consecutively for the **reset delay**.

3.2.10 "59 U>" protection – Maximum voltage

This protection is available **only for DST4602x**.

3.2.10.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0908.06	Linked/phase voltages	-	**DST4602x and GC400x**	0/1
P.0918	**Triggering threshold**	% P.0116	**DST4602x and GC400x**	60.0...150.0
P.0919	**Triggering delay**	s	**DST4602x and GC400x**	0.0..3200.0

Event codes	Description	Note
EVT.1101	Triggered protection	**DST4602x and GC400x**
EVT.1161	Protection reset	**DST4602x and GC400x**

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.060: triggered protection.	**DST4602x and GC400x**

P.0908.06 parameter allows deciding whether the protection works on mains linked voltages (0) or on phase voltages (1).

There are no parameters to configure the **reset threshold**.

There are no parameters to configure the **reset threshold.** It is calculated from the triggering threshold and from hysteresis (see 3.2.2.1). There are no parameters to configure **reset delay.** The delay is 700 ms.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.060 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.10.2 Description of operations

See diagram 3.2.3.2.

See the common notes in 3.2.4.

The protection is triggered when at least one mains voltage is above the **triggering threshold** consecutively for the **triggering delay**.

The protection is restored when all mains voltages are below **reset threshold** consecutively for the **reset delay**.

3.2.11 "81 f<<" protection – Minimum frequency

3.2.11.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0922	**Triggering threshold**	% P.0105		80.00...100.00
P.0923	**Triggering delay**	s		0.00...60.00

Event codes	Description	Note
EVT.1093	Triggered protection	
EVT.1153	Protection reset	**DST4602x and GC400x**.

Digital input functions	Description	Note
DIF.2708	Activates restrictive thresholds	**DST4602x and GC400x**.

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.055: triggered protection.	

The protection is enabled if:

- The **triggering delay** is different from 0.
- If there is a digital input configured with DIF.2708 function, this input should be active.

There are no parameters to configure the **reset threshold.** It is calculated from the triggering threshold and from hysteresis (see 3.2.2.2). There are no parameters to configure **reset delay.** The delay is 700 ms on **DST4602x and GC400x**, 0 ms on **GC500x**.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.055 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.11.2 Description of operations

See diagram 3.2.3.1.

See the common notes in 3.2.4.

The protection is triggered when mains frequency is below the **triggering threshold** consecutively for the **triggering delay**.

The protection is reset when the mains frequency is above the reset threshold consecutively for the **reset delay.**

3.2.12 "81 f<" protection – Minimum frequency

This protection is available **only for DST4602x and GC400x**.

3.2.12.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0926	**Triggering threshold**	% P.0105	**DST4602x and GC400x**	80.00...100.00
P.0927	**Triggering delay**	s	**DST4602x and GC400x**	0.0...3200.0

Event codes	Description	Note
EVT.1102	Triggered protection	**DST4602x and GC400x**
EVT.1162	Protection reset	**DST4602x and GC400x**

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.061: triggered protection.	

The protection can be disabled by setting the **triggering delay** to "0.0".

There are no parameters to configure the **reset threshold.** It is calculated from the triggering threshold and from hysteresis (see 3.2.2.2). There are no parameters to configure **reset delay.** The delay is 700 ms.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.061 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.12.2 Description of operations

See diagram 3.2.3.1.

See the common notes in 3.2.4.

The protection is triggered when mains frequency is below the **triggering threshold** consecutively for the **triggering delay**.

The protection is reset when the mains frequency is above the reset threshold consecutively for the **reset delay.**

3.2.13 "81 f>>" – Maximum frequency

3.2.13.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0924	**Triggering threshold**	% P.0105		100.0…120.0
P.0925	**Triggering delay**	s		0.00…60.00

Event codes	Description	Note

EVT.1094	Triggered protection	
EVT.1154	Protection reset	**DST4602x and GC400x**

Digital input functions	Description	Note
DIF.2708	Activates restrictive thresholds	**DST4602x and GC400x**

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.056: triggered protection.	

The protection is enabled if:

- The **triggering delay** is different from 0.
- If there is a digital input configured with DIF.2708 function, this input should be active.

There are no parameters to configure the **reset threshold.** It is calculated from the triggering threshold and from hysteresis (see 3.2.2.2). There are no parameters to configure **reset delay.** The delay is 700 ms on **DST4602x and GC400x**, 0 ms on **GC500x**.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.056 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.13.2 Description of operations

See diagram 3.2.3.2.

See the common notes in 3.2.4.

The protection is triggered when mains frequency is above the **triggering threshold** consecutively for the **triggering delay**.

The protection is reset when the mains frequency is below the **reset threshold** consecutively for the **reset delay**.

3.2.14 "81 f>" – Maximum frequency

This protection is available **only for DST4602x**.

3.2.14.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0928	**Triggering threshold**	% P.0105	**DST4602x and GC400x**	100.0…120.0
P.0929	**Triggering delay**	s	**DST4602x and GC400x**	0.0…3200.0

Event codes	Description	Note
EVT.1103	Triggered protection	**DST4602x and GC400x**
EVT.1163	Protection reset	**DST4602x and GC400x**

Digital Output functions	Description	Note

DOF.0103	AND/OR logic, with status ST.062: triggered protection.	

The protection can be disabled by setting the **triggering delay** to "0.0".

There are no parameters to configure the **reset threshold.** It is calculated from the triggering threshold and from hysteresis (see 3.2.2.2). There are no parameters to configure **reset delay.** The delay is 700 ms.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.062 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.14.2 Description of operations

See diagram 3.2.3.2.

See the common notes in 3.2.4.

The protection is triggered when mains frequency is above the **triggering threshold** consecutively for the **triggering delay**.

The protection is reset when the mains frequency is below the **reset threshold** consecutively for the **reset delay**.

3.2.15 Protection "81R" - Δf/Δt o ROCOF

This protection does not directly control mains frequency, but it controls speed frequency variations over time. This protection is not triggered due to slow changes in frequency, but intervenes immediately in case of fast changes (before frequency becomes too high or too low). It is possible to enable the protection to intervene on increases of frequency only, on decreases only, or both.

3.2.15.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0931	Triggering direction	-		1…3
P.0932	**Triggering threshold**	Hz/s		0.1…10.0
P.0933	**Triggering delay**	s		0.00…60.00

Event codes	Description	Note
EVT.1095	Triggered protection	
EVT.1155	Protection reset	**DST4602x and GC400x**.

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.057: triggered protection.	

The protection can be disabled by setting the **triggering delay** to "0.0".

P.0931 parameter allows enabling the protection for increases of frequency (1), decreases of frequency (2) or both (3).

This protection does not use any hysteresis on the triggering threshold. **The reset threshold**, then it corresponds to the triggering threshold. There are no parameters to configure **reset delay.** The delay is 700 ms on **DST4602x and GC400x**, 0 ms on **GC500x**.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.057 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.15.2 Description of operations

See the common notes in 3.2.4.

The protection is triggered when:

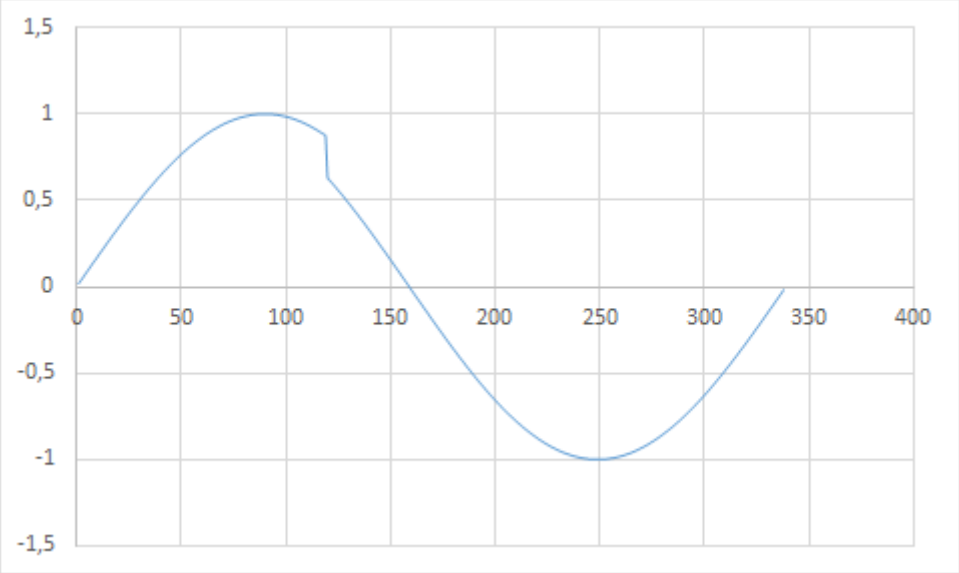
- The sign of the measure Δf/Δt is compatible with what configured with P.0931 parameter.
- The measure Δf/Δt is higher (in absolute terms) than the **triggering threshold**.
- The two previous conditions are verified consecutively for the **triggering delay**.

The protection is reset when:

- The sign of the measure Δf/Δt is not compatible with what configured with P.0931 parameter.
- The measure Δf/Δt is lower (in absolute terms) than the **reset threshold**.
- The two previous conditions are verified consecutively for the **reset delay**.

3.2.16 "78" protection – Vector surge

This protection applies a particular magnetic effect on the alternator taking place exactly when a fault occurs on the mains. The graph below shows this effect.



Actually, there is an instantaneous switch on the alternator (skip) of the voltage vectors (i.e. the period of the sinusoid where the fault occurs on the mains can be longer or shorter than the previous and next ones). This protection detects this skip. It is possible to configure the width of the skip (degrees) and the sign of the skip (the example shows a negative skip - the period lasts less than normal periods - but it could also happen the opposite).

3.2.16.1 Configuration

Parameter	Description	Unit	Note	Valid values
P.0941	Triggering direction	-		1…3
P.0942	**Triggering threshold**	°		0.0…30.0

Event codes	Description	Note
EVT.1096	Triggered protection	
EVT.1156	Protection reset	**DST4602x and GC400x**

Digital Output functions	Description	Note
DOF.0103	AND/OR logic, with status ST.058: triggered protection.	

The protection can be disabled by setting the **triggering threshold** to "0.0".

P.0941 parameter allows enabling the protection for positive phase skips (1), for negative phase skips (2) or both (3).

For this protection **there is no triggering delay**: the phase skip, in fact, happens only once (at the time of failure) and thus the protection should intervene immediately as soon as it is detected. Nor is there a **reset threshold**, since the period following the triggering is already a normal period. There are no parameters to configure **reset delay.** The delay is 700 ms on **DST4602x and GC400x**, 0 ms on **GC500x**.

Note: when the protection is triggered, the output configured with the AND/OR logics (ST.058 status) can be activated with a delay ranging from 0 to 10 ms compared to the outputs described in 3.2.4.2. It is preferable to use those outputs to control the opening of the switches.

3.2.16.2 Description of operations

See the common notes in 3.2.4.

The protection is triggered when:

- The sign of the phase skip measured is compatible with what configured with P.0941 parameter.
- The measured amplitude of the phase skip is higher (in absolute terms) than the **triggering threshold**.

The protection is reset when the reset delay from the **triggering has elapsed**.

3.3 Operation sequence

If the system allows the continuous parallel with the mains, it is mandatory that:

- Protections for the parallel with the mains are available. A digital input configured properly (see 3.1) should exist or, if the internal sensor is used, at least one of the described protections for the parallel with the mains 3.2 should be enabled.
- Select the switch which should act as "interface switch" (with P.0900 parameter).

The term "interface switch" identifies the switch (**MCB** or **GCB**) that will be opened immediately at the time when a protection for the parallel with mains is triggered. The opening of this switch should isolate the generator from the mains: depending on the selected switch, the users will stay connected to the mains or to the generator.

The interface switch should be opened within 0.5 seconds from the triggering of the protection (fixed non-configurable time): if it is not opened, **GCU** activates A275 shutdown (interface switch not open) and controls the opening of both **MCB** and **GCB** (to isolate the generator from mains). A275 shutdown cannot be disabled in any way.

GCU controls the opening of the interface switch exactly when the protections for the parallel with mains are triggered, but only if at that time the generator is in parallel with mains. If, for example, the interface switch is **MCB** (P.0900= 1), but the protections for the parallel with mains are triggered while **GCB** is open, **MCB** switch will not be opened.

For the systems that provide for the only production in "parallel with mains", when the protections are triggered, the generator is disconnected from the mains: the engine is however kept running to see if the fault on the mains is restored quickly and then production can restart. However, if mains

failure lasts longer than the time set by P.0899 parameter, **GCU** will stop the engine: it will be restarted later, when the fault on the mains is solved.

The parallel with mains is allowed only after P.0903 seconds from the time the fault on the mains is fixed. In particular, **GCU** waits P.0903 seconds before allowing parallel to mains since:

- All protections for the parallel with mains are restored.
- **DST4602x and GC400x**: voltages and frequency are within configured thresholds to allow the parallel (see 3.2.1). If this condition is not met, **GCU** displays a message on the status bar to inform the operator (see **GCU** technical manual).

4. Management of speed and tension regulators

To implement all the functions required by the parallel logics described below, **GCU** should be able to vary the frequency and the voltage produced by the generator. However **GCU** is not able to interact directly with engine and alternator electrical/ technical control devices. The generator should therefore be equipped with appropriate electronic control units denominated "speed controller" and "voltage regulator" that interact directly with these controls.

GCU should be connected to these controllers. Therefore, it "requires" a certain rotation speed at the rpm regulator and a certain voltage at the voltage regulator: then the same regulators will act on actual controls to make sure that the engine is running at the required speed and that the alternator supplies the required voltage.

The logics through which **GCU** creates the required speed and voltage for the regulators are described in the following chapters.

This chapter instead explains how to connect **GCU** to regulators.

In the rest of the document, the term "speed reference" refers to the speed request created by **GCU**. The term "voltage reference" refers to the voltage request created by **GCU**. Both references are expressed as percentages values 0...100%.

Installation note

During commissioning of the generator it is necessary to act on the trimmers of voltage and rpm regulators (if any) so that, by setting internal references to 50% (see below), the engine runs at the rated rotation speed and the alternator supplies the rated voltage.

It is possible to make minor adjustments directly from **GCU**. It often happens that with the default setting, the engine does not rotate exactly at 1500 rpm but, for example, it rotates at 1480 rpm. If it is difficult to act on the trimmer of the rpm regulator, it is possible to increase the internal speed reference (for example, by bringing it from 50.0% to 50.5%) to get the desired engine speed.

However avoid moving the internal reference to a value lower than 45% or higher than 55%. In these cases the adjustment dynamic is too unbalanced and this could give problems to the rpm and voltage regulators management function used for parallel logics.

Note for GC400x: on this controller it is possible to enable the controls of frequency and voltage, even during the island operation. Disable these controls before carrying out the previous operation (set P.1600 and P.1650 to zero). In this way, you are sure to have the dynamics of the regulation signals focused on the nominal values of frequency and voltage. Once these regulations are done, it is possible to enable the controls again (see the following chapters).

4.1 Connection to rpm regulator

GCU is able to connect to a rpm regulator in four different ways:

- Via a Can Bus line. State-of-the-art electronic engines, in fact, allow reading information and sending controls to the electronic control unit that controls the engine (ECU) via a Can Bus connection. All **GCUs** provide a CAN0 line just for this purpose. In this case, it is just required to:
    - Select the model of the engine with P.0700 parameter (in the list of supported engines).
    - Set the correct P.0703 parameter to enable **GCU** controls to the engine.

  See the documents [10] [11] for the description of supported engines.

  Normally, **GCU** internal speed reference 0 ... 100% is translated into a +/- 120 rpm speed variation compared to the rated speed regime.

- Through an analogue output. **GCU** devices provide for different types of analogue outputs:

- **DST4602x** has two standard current analogue outputs (mA) (insulated). They can be configured (by using micro-switches) as 0/20 mA, +/- 20mA or +/-10 mA. By applying an appropriate resistance on the two output terminals, they can be easily converted into voltage outputs.
- **GC500** has two series of PWM analogue outputs, which cannot be directly used for a connection to a rpm regulator. **SICES Srl** upon request provides an external module to convert PWM signals into current signals, which are identical to those described for **DST4602**.
- **GC500**^{Plus} e **GC500**^{Mains} provides the same two PWM outputs of **GC500** (see previous point). It also provides two voltage outputs (+/-10V or 0-20V) that can be used as an alternative to PWM outputs.
- **GC400x** provides two outputs in voltage (+/-10V).
- DANOUT. All **GCUs** support the DANOUT expansion module that provides four analogue outputs. The outputs can be configured (by using micro- switches) as 0-10mA, 0-20mA, 0-5V and 0-10V.

See **GCU** technical manuals for the connection to analogue outputs.

To use an analogue output for the rpm regulator control it is necessary to:

- Obsolete Use AOF.1000 function to configure the output.

  In this case it is possible to use three parameters to adapt the value of the output to the internal speed reference.

  P.0831 parameter allows specifying if the rpm control increases engine speed when the input control increases it (value 0 for P.0831), or if the engine speed decreases when the input control increases it (value 1 for P.0831, for example for the GAC regulators).

  P.0856 and P.0857 parameters can be used to set limit values (minimum and maximum respectively) that the analogue output can take. **P.0856 value should be lower than P.0857 value.**

  The internal speed reference will be scaled linearly between the values set in P.0856 and P.0857:

  - P.0831=0: if the internal reference is 0% (minimum speed), the analogue output will take P.0856 value; if the internal reference is 100% (maximum speed), the analogue output will take P.0857 value.
  - P.0831=1: if the internal reference is 0% (minimum speed), the analogue output will take P.0857 value; if the internal reference is 100% (maximum speed), the analogue output will take P.0856 value.
- **Suggested**. Use AOF.1001 function to configure the output. In this case, the scaling between the internal speed reference and the analogue output value should be performed through a conversion curve (see **GCU** technical manual). P.0831, P.0856 and P.0857 parameters are ignored.

- Through two digital outputs (UP/DOWN). This function is not supported by **GC400x**. **GCU** offers the following functions for the configuration of the digital outputs:
  - DOF.2221 (for **DST4602x**) or DOF.0050 (for **GC500x**). **GCU** generates pulses on this output to increase engine speed.
  - DOF.2222 (for **DST4602x**) or DOF.0051 (for **GC500x**). **GCU** generates pulses on this output to decrease engine speed.

- DOF.2223 (for **DST4602x**) or DOF.2223 (for **GC500x**). This control is optional and can be used only on rpm regulators which provide for the appropriate input. **GCU** activates this output when it wants to bring engine rpm back to rated value. **Do not configure any output with this function if rpm controller does not provide for an own input.**

If you UP/DOWN controls are used, appropriately configure the following parameters:

- P.0992 parameter: in this parameter it is necessary to set the theoretical time (s) that the rpm regulator needs to bring the engine from minimum to maximum speed.
- P.0993 parameter: in this parameter it is necessary to set the time (s) for pulses (there will be only one pulse every P.0993 seconds).
- P.0994 parameter: in this parameter it is necessary to set the minimum duration of the pulse (%). It is a percentage of the time set in P.0993.
- P.0995 parameter: in this parameter it is necessary to set the minimum duration of the pulse (%). It is a percentage of the time set in P.0993.

GCU will generate a single UP or DOWN pulse every P.0993 seconds: the output will be activated for a time included between P.0994 and P.0995 (% of P.0993), based on the frequency error/active power. P.0992 parameter is used internally to **GCU** for its management logics: it is not necessary for it to be fully precise. Normally it is possible to measure it by bringing the engine to minimum speed (forcing a fixed "DOWN" control): then, by forcing a fixed "UP" control, the time the engine takes to reach full speed is measured.

If the digital output is not used to force the engine to rated rpm speed, GCU should control the speed even when the generator is not in parallel with anything. Remember in these cases to correctly set P.0849 and P.0850 parameters for frequency PI controller, to allow proper adjustment of speed. **GCU** converts the internal speed reference in a +/- 4 Hz variation compared to the nominal frequency (+/- 120 rpm compared to rated speed).

- Through a PWM control (only **GC500**^{Plus} and **GC500**^{Mains}). One of 10, 11 or 12 digital outputs can be configured (DOF.0049) to supply an output to a PWM control to adjust the rpm speed of the engine. The frequency of PWM signal is 500Hz, suitable for the Caterpillar rpm controllers. In this case P.0831, P.0856 and P.0857 parameters can be used to convert internal speed reference into an appropriate duty-cycle: P.0856 and P.0857 determine the minimum and maximum duty cycle (%).

4.2 Voltage regulator management

GCU is able to connect to a voltage regulator in two different ways:

- Through an analogue output. See paragraph 4.1 for a description of analogue outputs provided by **GCU**. See **GCU** technical manuals for the connection to analogue outputs.

  To use an analogue output to control the voltage regulator it is necessary to:

  - Obsolete. Use AOF.1002 function to configure the output.

    In this case three parameters can be used to adapt the output value to the internal voltage reference.

    P.0861 parameter allows indicating whether the voltage regulator increases alternator voltage when the input control increases it (value 0 for P.0861), or if the alternator voltage decreases when the input control increases it (value 1 for P.0861).

    P.0862 and P.0863 parameters can be used to set limit values (minimum and maximum respectively) that the analogue output can take. **P.0862 value should be lower than P.0863value.**

The internal voltage reference will be scaled linearly between the values set in P.0862 and P.0863:

- P.0861=0: if the internal reference (minimum voltage) is 0%, the analogue output will take P.0862 value; if the internal reference (maximum voltage) is 100%, the analogue output will take P.0863 value.
- P.0861=1: if the internal reference (minimum voltage) is 0%, the analogue output will take P.0863 value; if the internal reference (maximum voltage) is 100%, the analogue output will take P.0862 value.

- **Suggested**. Use AOF.1003 function to configure the output. In this case, the scaling between the internal speed reference and the analogue output value should be performed through a conversion curve (see **GCU** technical manual). P.0861, P.0862 e P.0863 parameters are ignored.

- Through two digital outputs (UP/DOWN). This function is not supported on **GC400x.** **GCU** offers the following functions for the configuration of the digital outputs:
  - DOF.2211 (for **DST4602x**) or DOF.0053 (for **GC500x**). **GCU** generates pulses on this output to increase alternator voltage.
  - DOF.2212 (for **DST4602x**) or DOF.0054 (for **GC500x**). **GCU** generates pulses on this output to decrease alternator voltage.
  - DOF.2213 (for **DST4602x**) or DOF.0055 (for **GC500x**). This control is optional and can be used only on voltage regulators that provide the appropriate input. GCU activates this output when it wants to bring the alternator voltage back to rated value. **Do not configure any output with this function if the voltage regulator does not provide for its own input.**

  If you UP/DOWN controls are used, appropriately configure the following parameters:
  - P.0996 parameter: in this parameter it is necessary to set the theoretical time (s) that the regulator needs to bring the alternator from minimum to maximum voltage.
  - P.0997 parameter: in this parameter it is necessary to set the time (s) for pulses (there will be only one pulse every P.0997 seconds).
  - P.0998 parameter: in this parameter it is necessary to set the minimum duration of the pulse (%). It is a percentage of the time set in P.0997.
  - P.0999 parameter: in this parameter it is necessary to set the minimum duration of the pulse (%). It is a percentage of the time set in P.0997.

  GCU will generate a single UP or DOWN pulse each P.0997 seconds: the output will be activated for a time included between P.0998 and P.0999 (% of P.0997), based on the voltage/reactive power error. P.0996 parameter is used internally to **GCU** for its management logics: it is not necessary for it to be fully precise. Normally it is possible to measure it by bringing the alternator to minimum voltage (forcing a fixed "DOWN" control): then, by forcing a fixed "UP" control, the time the alternator takes to reach full voltage is measured.

  If you do not use the digital output to force the alternator to rated voltage, **GCU** should check the voltage also when the generator is not in parallel with anything. Remember in these cases to correctly set P.0868 and P.0869 parameters for PI voltage controller, to allow proper voltage regulation. **GCU** converts internal voltage reference in a +/- 10% variation of rated voltage.

4.3 Nominal power

For all parallel functions the correct setting of nominal values for active power and apparent power of the generator is essential. **GCU** provides the following parameters:

- P.0125 (kW). Here the rated power of the engine should be set. This parameter is used for engine protections, but is also used by parallel logics for the management of active power: in fact they always work on percentage active power, that is calculated on the basis of this parameter. **Avoid changing this value after setting the coefficients for PI controller: it may be necessary to repeat the calibration of these regulators.**
- P.0106 (kVA). Here it is necessary to set the rated power of the alternator (kVA), which is usually higher than the rated power of the engine (because the alternator should be able to provide also a part of reactive power). This parameter is used for the protections of the alternator.

From the two previous parameters GCU draws rated reactive power:

$$Q_n = \sqrt{P.0106^2 - P.0125^2}$$

The value Qn is used by some of parallel logics for the management of reactive power: in fact they always work on percentage reactive power, that is calculated on the basis of this parameter. **Avoid changing this value after setting the coefficients for PI controller: it may be necessary to repeat the calibration of these regulators.**

4.4 PI regulators

GCU internally uses several PI regulators, in order to determine the voltage and speed references needed in every instant to manage the generator during prior and subsequent stages to parallel with mains or with other generators. With **GC400x**, it is possible to enable the PI regulators even if the genset does not work in parallel with the mains or with other gensets. All internal PI regulators are configured with two parameters:

- The factor proportional to current error (P), also called "gain".
- The factor related to the integral in error time (I), also called "integrative factor".

In the following chapters the parameters associated with each PI regulator will be indicated.

These two parameters for each PI regulator should be "calibrated" on the field during the commissioning of the generator. In fact they depend on several factors: type of engine, alternator power, type of alternator; different parameters for similar systems may also be required.

However, setting these parameter is not very critical if carried out following a correct procedure. Unfortunately, the empirical setting-up method (called Ziegler-Nichols) requires measuring the period of oscillation of controlled condition (frequency, voltage, active power, reactive power), measurement that is not always possible (or easier) to perform.

For this reason, beside the empirical method, we suggest a simplified one that should allows to properly select the relevant parameters.

PI controllers parameters can also be modified while the system is running, even from the operator panel. It is advisable to make changes using the BoardPrg3 program, available free of charge on **SICES Srl's** website.

4.4.1 Full method

1) Set "P" at an initial value (0.100) and "I" at 0000.
2) Increase "P" until the controlled condition starts to oscillate (for example, if you are adjusting the IP that manages the engine speed during synchronization, increase "P" until

"by ear" you start hearing the engine that continually accelerates/slows down). Decrease/increase the value of "P" until the starting point of the oscillation is singled out (a good approximation is enough).

3) Measure the period of oscillation (the time between two consecutive speed peaks).

4) Set "P" to a slightly lower value than the one obtained by dividing the current value by 2.2.

5) Set the "I" to the calculated value by dividing 1.2 for the oscillation period measured before (in seconds). It can be set a lower value degrading the performance but increasing stability margin.

6) Some other fine tuning might be necessary. Verify how the system work with low, medium and high load. In case there is still an instability of the system, reduce further the value of "P".

4.4.2 Simplified method

To overcome the difficulties of measuring the period of oscillation, it is possible to go on, referring to what said in the previous paragraph, from step 6 included, excluding points 3 and 5. Instead of step 5, increase/decrease "I" (after arranging "P" at step 4) to achieve the optimal performance.

4.4.3 General remarks

P factor is not able by itself to perform a good regulation. To reduce the error, P should be increased, but after a threshold, the system becomes instable. Usually the P value set using the explained method is the better compromise between performance and stability.

To get a good adjustment, it is necessary to set "I" factor. Even small values of the parameter "I" increase the performance of the system. Value, obtained used the explained method, usually give the better performance. However it is not critical and can be set in a wide range of values.

Remember that the factor "I" accumulates adjustment errors: delays in the recovery of the error can cause over-elongations (over-shoots) or under-elongations (under-shoots). Moreover, too high value of “I” lead to system instability.

Once the value that gives a good performance is found, try to decrease it until the performance drops below the expected minimum. Then select the actual value in that range as compromise

In some cases, could be necessary to start the procedure with a minimum “I” value to allow the controller a minimum regulation capability compatible with the system. A very small value of "I" (0.01) can be used with minimal effect on the procedure.

5. Supply mode

This chapter describes the actions of **GCU** on voltage regulators and speed controls, based on the type of system, the status of the engine and to the status of the switches. For each function, parameters and functions used for the configuration of the inputs and outputs are described.

5.1 "Fine tuning"

5.1.1 "Fine tuning" of frequency

As already described in 4, it is possible to adjust the engine rotation speed (and consequently the frequency of the alternator) by acting on **GCU** instead of on the rpm regulator. The adjustment made in this way ("fine tuning"), will be used as a "basic control" for the rpm regulator, the starting point for the various PI regulators, which are used in the logics described as follows.

With all the controllers except for **GC400x**, when the genset works in isochronous and it is not in parallel with neither mains nor other gensets, the command that is sent to the rpm regulator is equal to the "fine tuning" value. In these conditions, indeed, no phase regulation is required (as during the synchronisation), as well as the active power (set by the load). The frequency regulation is managed by the rpm regulator that will increase/decrease the fuel flow to the engine in order to guarantee that the frequency is the one required with the "fine tuning" command.

By default, **GC400x** works in the same way too. Anyhow, it is possible to enable the control of the frequency (see 5.2) with the parameters:

- P.1600.0: it enables the frequency control when GCB is open.
- P.1600.1: it enables the frequency control when the GCB is closed and the genset works in isochronous and it is not in parallel with neither mains nor other gensets.

GCU provides P.0840 parameter for the "fine tuning" of frequency. It is a percentage value: the value of 50 % should correspond to the rated speed of the engine, the value of 0% should correspond to the minimum speed and the value of 100 % to the maximum speed. On electronic engines, the variation of control between 0 and 100 % causes a variation of 240 rpm (8 Hz) around the rated speed (+/- 120 rpm, +/- 4 Hz). On engines with conventional rpm regulators, it should be necessary to guarantee a similar dynamic by acting on the same rpm regulator and/or on the minimum and maximum values that the analogue output can take (see 4.1).

P.0840 parameter can be varied directly from **GCU** panel, even with the generator running. All **GCUs** provide for a display page (the one linked to the synchronization, see the operating manual) that enables the modification of this parameter without getting into programming.

As an alternative to P.0840 parameter, it is possible to use an analogue input to perform the "fine-tuning" (normally connected to a potentiometer on the front panel). If an analogue input is used, P.0840 parameter is no longer used and it is not therefore possible to vary the frequency from **GCU** panel. In any case, on the display page devoted to synchronization, **GCU** shows the "fine tuning" value acquired by the analogue input. The analogue input should be configured as follows:

- **DST4602x**.
    - **Obsolete** Using AIF.2100 function. In this case, P.0838 and P.0839 parameters are used for scaling the analogue input. When the input takes the value configured in P.0838, the "fine adjustment" is set to 0%. When the analogue input takes the value configured in P.0839, the "fine tuning" is set to 100%. It is possible to set P.0838 to a value greater than P.0839, therefore getting a "reverse adjustment": when the value acquired by the analogue input increases, the value of the "fine tuning" decreases.
    - **Suggested.** Using AIF.2101 function. In this case, the conversion between the value acquired by the analogue input and the "fine-tuning" is performed via a conversion curve see operating instructions).
- **GC400x**.

- Using the function AIF.2101. In this case, the conversion from the value acquired by the analogue input and the “fine tuning” is carried out through a conversion curve (see the user manual).

- **GC500x**.

  - **Obsolete** It is necessary to select an analogue input through P.0837 parameter (any value other than "0" and "7"). In this case, there is no need to configure anything in the parameters related to the selected analogue input, and P.0838 and P.0839 parameters are used for scaling the analogue input. See description above for **DST4602x**.

  - **Suggested.** Setting the value "7" in P.0837 parameter. In this case it is necessary to configure the analogue input with the desired AIF.2101 function (see description above for **DST4602x**).

It is also possible (but not mandatory) to use a **GCU** digital input to decide whether to acquire the value for the "fine tuning" of the frequency from the analogue input or whether to use P.0840 parameter. Configure the input with DIF.2711 function:

- If the input is active, the value for the "fine tuning" of the frequency is acquired by the analogue input.

- If the input is not active, the value for the "fine tuning" of the frequency is P.0840 parameter.

If the system is composed of several generators, the procedure for the "fine tuning" of speed should be performed on all generators to obtain the same rotation speed (or the same frequency). If this is not performed, then there will be problems in the active power distribution phase (except for **GC400x** as in 5.5).

NOTE: if there is a potentiometer for the "fine tuning" of speed, it should not be used to request more or less active power when the generator is in parallel with the mains or with another generator.

5.1.2 “Fine tuning” of voltage

As described in paragraph 4, it’s possible to correct the voltage of the alternator by managing the GCU instead of the voltage regulator. This regulation, called “fine tuning, will be used as “basic command” for the voltage regulator, the starting point for the various PI regulators, which are used in the parallel logics.

With all the controllers except for **GC400x**, when the genset works in isochronous and it is not in parallel with neither mains nor other gensets, the command that is sent to the voltage regulator is equal to the “fine tuning” value. In these conditions, indeed, no reactive power is required (set by the load). The voltage regulation is managed by the voltage regulator that will increase/decrease the alternator excitation current in order to guarantee that the voltage is the one required with the “fine tuning” command.

By default, **GC400x** works in the same way too. Anyhow, it is possible to enable the control of the voltage (see 5.2) with the parameters:

- P.1650.0: it enables the voltage control when GCB is open.

- P.1600.1: it enables the frequency control when the GCB is closed and the genset works in isochronous and it is not in parallel with neither mains nor other gensets.

GCU provides P.0867 parameter for the "fine tuning" of voltage. It is a percentage value: the value of 50 % should correspond to the rated voltage of the alternator, the value of 0% should correspond to the minimum voltage and the value of 100 % to the maximum voltage. It should be necessary to guarantee a dynamic of +/- 10% out of the nominal voltage, by managing the voltage regulator and/or on the minimum and maximum values that the analogue output can take (see 4.1).

P.0867 parameter can be varied directly from **GCU** panel, even with the generator running. All **GCUs** provide a display page (the one linked to the synchronization, see the user's manual) that enables the modification of this parameter without getting into programming.

As an alternative to P.0867 parameter, it is possible to use an analogue input to perform the "fine-tuning" (normally connected to a potentiometer on the front panel). If an analogue input is used, P.0867 parameter is no longer used and it is not therefore possible to vary the frequency from **GCU** panel. In any case, on the display page devoted to synchronization, **GCU** shows the "fine tuning" value acquired by the analogue input. The analogue input should be configured as follows:

- **DST4602x**.
    - **Obsolete.** Using AIF.2200 function. In this case, P.0865 and P.0866 parameters are used for scaling the analogue input. When the input takes the value configured in P.0865, the "fine tuning" is set to 0%. When the analogue input takes the value configured in P.0866, the "fine tuning" is set to 100%. It is possible to set P.0865 to a value greater than P.0866, therefore getting a "reverse adjustment": when the value acquired by the analogue input increases, the value of the "fine tuning" decreases.
    - **Suggested.** Using AIF.2201 function. In this case, the conversion between the value acquired by the analogue input and the "fine tuning" is performed via a conversion curve see operating instructions).
- **GC400x**.
    - Using the function AIF.2201. In this case, the conversion from the value acquired by the analogue input and the "fine tuning" is carried out through a conversion curve (see the user's manual).
- **GC500x**.
    - **Obsolete.** It is necessary to select an analogue input through P.0864 parameter (any value other than "0" and "7"). In this case, there is no need to configure anything in the parameters related to the selected analogue input, and P.0865 and P.0866 parameters are used for scaling the analogue input. See description above for **DST4602x**.
    - **Suggested.** Setting the value "7" in P.0864 parameter. In this case it is necessary to configure the analogue input with the desired AIF.2101 function (see description above for **DST4602x**).

If the system is composed of several generators, the procedure for the "fine tuning" of speed should be performed on all generators to obtain the same rotation speed (or the same frequency). If this is not performed, then there will be problems in the active power distribution phase (except for **GC400x** as in 5.5).

NOTE: if there is a potentiometer for the "fine tuning" of speed, it should not be used to request more or less active power when the generator is in parallel with the mains or with another generator.

5.2 Supply in non-parallel mode

This description is applied when the genset is not in parallel neither with the mains nor with other gensets, and if the DROOP mode is not activated (otherwise see 0).

In these conditions, the controller doesn't need any power regulation (neither active nor reactive), because it is set by the load connected to the genset. Generally, the genset has to maintain constant frequency and voltage (and the values desired) in any load condition. Usually, this is the function of rpm and voltage regulators: they accept a frequency or voltage "setpoint" and regulate the fuel flow or the excitation current to maintain the real voltage and frequency equal to the setpoint.

In this phase, GCU has no need to change the “setpoint” for the rpm and voltage regulators: usually, GCU commands correspond to what has been set with the “fine tuning” procedure. Therefore, generally no PI regulator is active (except when UP/DOWN commands are used for the rpm and voltage regulators).

With GC400x, there is the possibility to enable the PI regulators in this phase too. This possibility is optional, and must be specifically requested through parameters (see the following paragraphs).

It is possible to configure a digital output with the function DOF.0103 (AND/OR logics) with the status ST.104: the output activates when the genset is supplying but it is not in parallel neither with the mains nor with other gensets.

5.2.1 Frequency regulation

This description is valid for **GC400x** only.

The PID for the frequency regulation must be clearly enabled:

- P.1600.0: it enables the frequency control when GCB is open.
- P.1600.2: it enable the frequency control when GCB is closed and the genset works in isochronous and it is not in parallel neither with the mains nor with other gensets.

If it is disabled, refer to paragraph 5.2, as per the other controllers.

The plus of enabling the regulation PI is that the system is no longer subject to little analogue command faults. Even if there were changes of GCU values and speed regulator, GCU would vary the command until the frequency measured will be the one required.

If the PI is enabled, **GCU** set P.1604 as “frequency set point”. It is a value expressed in Hz. P.1604 parameter can be changed directly through the **GCU** display, even if the genset is running. GCU display provides a page (related to the synchronization, see the user’s manual) that allows to change this parameter without entering the programming. **Note: the parameter P.1604 is automatically shared among all the GCU connected to the CanBus PMCB.**

As an alternative to the parameter P.1604, it is possible to use an analogue input to acquire the “frequency set point” (usually connected to a potentiometer on the panel). By using an analogue input, the P.1604 parameter is no longer used and it’s not possible to change the frequency set point on **GCU**. Anyhow, on the display page dedicated to the synchronization, **GCU** shows the “frequency set point” value acquired by the analogue input. The analogue input must be configured using the function AIF.2111. In this case, the conversion between the value acquired by the analogue input and the “frequency set point” is carried out through a conversion curve (see user’s manual). **Note: the frequency set point acquired by an analogue input is not shared among all the GCU connected on the CanBus PMCB.**

The parameters that configure the PI regulator for the frequency regulation are P.0977 and P.0978. By setting them at zero, the PI regulator is disabled. See 4 for the configuration of these two parameters.

The frequency control, even if it is disabled, does not work with engine stopped or during the engine start operations. It starts working after P.1602 seconds since the frequency or the engine rounding have overpassed the P.1061 percentage value (with respect to the nominal one). Additionally, GCU follows the “frequency set point” variation with a ramp, which is configurable using the P.1603 parameter.

5.2.2 Voltage regulation

This description is valid for **GC400x** only.

The PID for the frequency regulation must be clearly enabled:

- P.1650.0: it enables the voltage control when GCB is open.

- P.1600.2: it enable the voltage control when GCB is closed and the genset works in isochronous and it is not in parallel neither with the mains nor with other gensets.

If it is disabled, refer to paragraph 5.2, as per the other controllers.

The plus of enabling the regulation PI is that the system is no longer subject to little analogue command faults. Even if there were changes of GCU values and voltage regulator, GCU would vary the command until the frequency measured will be the one required.

If the PI is enabled, **GCU** set P.1654 as “frequency set point”. It is a value expressed in Hz. P.1604 parameter can be changed directly through the **GCU** display, even if the genset is running. GCU display provides a page (related to the synchronization, see the user’s manual) that allows to change this parameter without entering the programming. **Note: the parameter P.1654 is automatically shared among all the GCU connected to the CanBus PMCB.**

As an alternative to the parameter P.1654, it is possible to use an analogue input to acquire the “voltage set point” (usually connected to a potentiometer on the panel). By using an analogue input, the P.1654 parameter is no longer used and it’s not possible to change the voltage set point on **GCU**. Anyhow, on the display page dedicated to the synchronization, **GCU** shows the “voltage set point” value acquired by the analogue input. The analogue input must be configured using the function AIF.2211. In this case, the conversion between the value acquired by the analogue input and the “voltage set point” is carried out through a conversion curve (see user’s manual). **Note: the voltage set point acquired by an analogue input is not shared among all the GCU connected on the CanBus PMCB.**

The parameters that configure the PI regulator for the voltage regulation are P.0989 and P.0990. By setting them at zero, the PI regulator is disabled. See 4 for the configuration of these two parameters.

The voltage control, even if it is disabled, does not work with engine stopped or during the engine start operations. It starts working after P.1652 seconds since the genset voltage has overpassed the P.1651 percentage value (with respect to the nominal one). Additionally, GCU follows the “frequency set point” variation with a ramp, which is configurable using the P.1653 parameter.

5.3 Supply in DROOP mode

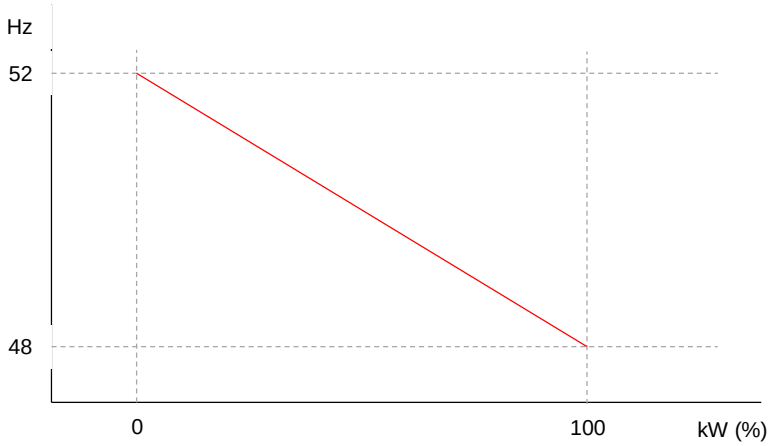
GCU controls the DROOP mode only with **GCB** closed. Until **GCB** is open, what said in 5.1 and **Errore. L'origine riferimento non è stata trovata.** is valid.

The DROOP mode is available for both frequency and voltage.

5.3.1 Droop for frequency.

Note: If there is an active digital input configured with DIF.2095 function (for **DST4602x and GC400x**) or DIF.0058 (for **GC500x**), the DROOP mode is disabled and the rpm regulator is controlled as shown in 5.1.

The management in DROOP of the rpm regulator consists in requiring the same rpm regulator a speed (frequency) depending on the currently supplied active power, according to a curve indeed called DROOP curve. It is actually a straight line. The next picture shows an example:



In the previous example, the curve provides a no-load frequency of 52 Hz and a full-load frequency of 48 Hz.

The DROOP adjustment is used to put two generators in parallel and get a breakdown of active power, without plugging in any way the control devices of the two generators between them. It should only be used to put in parallel a generator run by a **GCU SICES Srl** device with another generator not managed by non-**SICES Srl** devices. It makes little sense to use the DROOP adjustment for a generator that supplies in parallel to mains: as the frequency is imposed by the mains, that generator would provide a (fixed) power as indicated by the DROOP curve (in the example of the previous figure, if mains frequency is 50 Hz, the generator would always supply 50% of its rated power).

The distribution of active power in DROOP works only if the DROOP curve is identical on all generators.

As the generators which supply in DROOP are not connected to each other in any way, the idea is to use the only information in common among them (frequency) as index of the power to be supplied.

Let's take an example with only two generators, assuming to use the DROOP curve shown in the figure above. Let's suppose to have a 100-kW generator and a 200-kW generator. Let's suppose that the load is 80 kW. Finally, let's suppose to start with a single generator that supplies the load (G1 the 100-kW one).

- G1 generator supplies the full load (80 kW) and therefore supplies 80% of its rated power. According to the DROOP curve, 80% of the power should work at a frequency of 48.8 Hz. Therefore, it orders the rpm regulator to work at that frequency and, not being in parallel with anything, after a few sinusoids it actually supplies 80 kW at 48.8 Hz.
- G2 generator (200 kW) closes its **GCB** and so it is in parallel with G1 (without knowing it). As soon as it gets into parallel, G2 is without load and then, based on the DROOP curve, it should work at 52 Hz. Therefore it orders the rpm regulator to work at 52 Hz.
- The previous control of G2 has the immediate effect of causing the transfer of part of the load from G1 to G2 (because the rpm regulator of G2 requires a higher speed than that of G1). In the long term it also has the effect of a rise in the frequency of both generators (that is the same, as they are in parallel). Suppose that 40 kW are transferred from G1 to G2.
- At this point, both generators are delivering 40 kW.
    - G1: 40 % of rated one. It should work at 50.4 Hz.
    - G2: 20% of rated one. It should work at 51.2 Hz.

  Both generators try to control the frequency as required by the load. As you can see, G2 still requires an higher frequency than G1: this again causes a load transfer from G1 to G2. Let's suppose that additional 10 kW are transferred to G2.
- At this point there is:

- G1: 30 kW (30%) of rated one. It should work at 50.8 Hz.
- G2: 50 kW (25%) of rated one. It should work at 51.0 Hz.

Both generators try to control the frequency as required by the load. As you can see, G2 still requires an higher frequency than G1: this again causes a load transfer from G1 to G2.

- In the long term the two generators will have a load that requires the same frequency:
  - G1: 26.66 kW (26.66 %) of rated one. It should work at 50.9333 Hz.
  - G2: 53.33 kW (26.66 %) of rated one. It should work at 50.9333 Hz.

As you can see, the system settles down with a breakdown of the correct percentage of power, to the prejudice of frequency. The limit of the breakdown of active power in DROOP is, as a matter of fact, that it operates at a variable frequency, which depends both on the total load and on the number of machines in parallel.

Two different managements for the frequency DROOP are available.

DROOP managed directly by the rpm regulator.

On conventional rpm regulators, this mode is activated by a contact (or is set by a trimmer on the rpm regulator). On **GCU** it is not necessary to do anything, and indeed, **GCU** does not even know that the DROOP mode has been activated.

For some electronic engines with Can-Bus communication, it is possible enable the DROOP directly on the rpm regulator by setting the P.0708 parameter to 1 (see [10] [11]).

DROOP managed by GCU.

If the DROOP should be managed by **GCU**, it should be specifically requested with a digital input configured with DIF.2094 function (for **DST4602x and GC400x**) or DIF.0061 (for **GC500x**). When the input is activated, the DROOP mode is active (if **GCB** is closed).

GCU defines the curve for the frequency DROOP with two values: the working frequency when the generator is without load ("load frequency") and the slope of the curve. These two values can be set with **GCU** parameters.

P.0974 parameter allows defining the "load frequency" (Hz), i.e. the working frequency that should be guaranteed when the generator is without load. This parameter can be modified on **GCU** even when the engine is running. All **GCUs** allow the modification of this parameter (when the DROOP mode is active) directly from the display page that shows the single-line system diagram. As an alternative to this parameter, it is possible to use an analogue input to acquire the value of "no-load frequency". In this case, the "no-load frequency" will no longer be adjustable from the **GCU** panel (P.0974 is ignored), but it will be anyway displayed:

- **DST4602x**.
  - **Obsolete**. Configure the desired analogue input with AIF.2304 function. In this way, the conversion of the value acquired by the analogue input in "no-load frequency" is performed with P.0972 and P.0973 parameters. The "no-load frequency" for the DROOP will be set up in P.0972 when the analogue input is at its minimum value (0%); it will be the one configured with P.0973 when the analogue input is at its maximum value (100%). By setting P.0972 to a value higher than P.0973 a reverse scaling will be achieved (when the measure acquired by the analogue input increases, the "no-load frequency" decreases).
  - **Suggested**. Configure the desired analogue input with AIF.2305 function. In this way, the conversion of the value acquired by the analogue input in "no-load frequency" is performed via a conversion curve (see technical manual).

Note: starting from **DST4602x** version 00.48, it is possible to use another digital input to decide if using the analogue input or the parameter P.0974 to set the “no-load frequency”. That input will be configured with the DIF.2714 function. The possibilities are:

- If no analogue input is configured with the AIF.2304 or AIF.2305 function, the set point is established by the parameter P.0974.
- If there is an analogue input configured with the AIF.2304 or AIF.2305 function:
  - The set point is established by the analogue input if there are no digital input configured with the function DIF.2714.
  - The set point is established by the analogue input if there is at least one digital input configured with the function DIF.2714.
  - The set point is established by the parameter P.0974 if all the digital inputs configured with the DIF.2714 function are in stand-by.

- **GC400x**.

  Configure the analogue input with AIF.2305 function. In this way, the conversion of the value acquired by the analogue input in "no-load frequency" is performed by a conversion curve (see technical manual). It is possible to use another digital input to decide if using the analogue input or the parameter P.0974 to set the "no-load frequency". That input will be configured with the function DIF.2714. The possibilities are:

  - If no analogue input is configured with the AIF.2305 function, the set point is established by the parameter P.0974.
  - If there is an analogue input configured with the AIF.2305 function:
    - The set point is established by the analogue input if there are no digital input configured with the function DIF.2714.
    - The set point is established by the analogue input if there is at least one digital input configured with the function DIF.2714.
    - The set point is established by the parameter P.0974 if all the digital inputs configured with the DIF.2714 function are in stand-by.

- **GC500x**.
  - **Obsolete** It is necessary to select an analogue input through P.0971 parameter (any value other than "0" and "7"). In this case, there is no need to configure anything in the parameters related to the selected analogue input, and P.0972 and P.0973 parameters are used for scaling the analogue input. See description above for **DST4602x**.
  - **Suggested.** Setting the value "7" in P.0971 parameter. In this case it is necessary to configure the analogue input with the desired AIF.2305 function (see description above for **DST4602x**).

GCU allows setting the slope of the frequency DROOP curve via P.0975 parameter (%/Hz). It indicates which percentage of the generator rated power (P.0125) corresponds to a decrease of 1 Hz of working frequency. The image above shows a curve for the DROOP allowing a total range of 4 Hz passing from 0% through 100% of the generator power: the value for P.0975 parameter to configure the previous curve would be 25 %/Hz.

As mentioned above, working with DROOP means imposing a working frequency according to the present load. Since **GCU** interfaces with a rpm regulator (whose job is to ensure that the engine works at the speed required externally), in principle it is not necessary to use a PI regulator on **GCU**: it is enough to calculate the number of rounds corresponding to the present load and request it to the rpm regulator. This is especially true for electronic engines (Can Bus), where GCU is able to

require the exact number of desired rpm with extreme precision. Even with the traditional rpm regulators it is possible to work without a PI regulator: in this case **GCU** expects the engine to react with a +/- 120 rpm variation passing from the minimum value to the maximum value of the control analogue output. Instead, using a rpm regulator with UP/DOWN controls, it is mandatory to use the PI controller on **GCU**.

The parameters that configure the PI regulator for the frequency DROOP are P.0977 and P.0978. By setting them both to zero the PI regulator will be disabled. See 4 for the adjustment of the two parameters.

Note for **GC400x**: for this GCU it is necessary to clearly enable the frequency regulation during the DROOP by means of the P.1600.4 (it is not sufficient to set P.0977 and P.0978 different from zero).

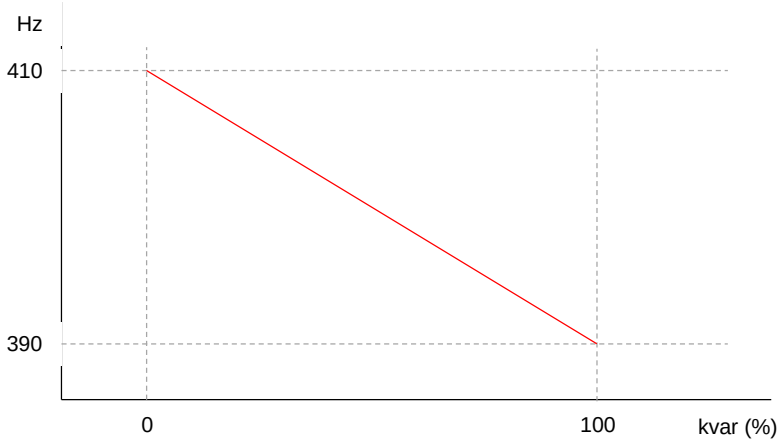
As a rule, the DROOP is used for the parallel with the generators controlled by non **SICES Srl** devices. It is not used for the parallel with mains. As a rule, therefore, the **GCU** working in DROOP does not know it is in parallel with something else: therefore, it cannot manage the loading and unloading phases in the stages of entry into and exit from parallel. If however **GCU** knows it is in parallel with something else (for example, if it is used in DROOP also in parallel with mains), then it can manage loading and unloading phases. P.0976 parameter is used to configure loading and unloading phases (Hz/s): it indicates the maximum speed at which **GCU** modifies its internal frequency setpoint.

See notes in 5.3.3

5.3.2 Voltage DROOP.

Note: if there is an active digital input configured with DIF.2095 (for **DST4602x and GC400x**) or DIF.0058 (for **GC500x**) functions, the DROOP mode is disabled and the voltage regulator is controlled as indicated in **Errore. L'origine riferimento non è stata trovata.**.

The management in DROOP of the voltage regulator consists in requiring the same voltage regulator a voltage that depends on the currently delivered reactive power (kvar), according to a curve indeed called DROOP curve. It is actually a straight line. The next picture shows an example:



In the previous example, the curve provides a no-load voltage of 410 Vac and a full-load voltage of 390 Vac 48 Hz for the maximum reactive power.

The DROOP adjustment is used to put two generators in parallel and get a breakdown of active power, without plugging in any way the control devices of the two generators between them. It should only be used to put in parallel a generator run by a **GCU SICES Srl** with another generator managed by non-**SICES Srl** devices. It makes little sense to use the DROOP adjustment for a generator that supplies in parallel to mains.

The distribution of active power in DROOP works only if the DROOP curve is identical on all generators.

As the generators which supply in DROOP are not connected to each other in any way, the idea is to use the only information in common among them (frequency) as index of the power to be supplied The limit of reactive power breakdown in DROOP is that it operates at a variable voltage, which depends both on the total reactive load and on the number of machines in parallel.

See 5.3.1 for an example of management in DROOP (the example is for the frequency DROOP, but it is also valid for the voltage DROOP if voltage instead of frequency and reactive power instead of active power are used).

Conversely to frequency DROOP, in the voltage DROOP the curve extends also above no-load voltage. Looking at the picture above, in fact, the generator will be at 410 Vac 0 kvar, will decrease to 390Vac for maximum inductive reactive load (exported reactive power), but will rise above 410 Vac in case of capacitive reactive load (imported reactive power).

There are two different managements for voltage DROOP.

DROOP managed directly by the voltage regulator.

On voltage regulators, normally this mode is activated through a trimmer (if set to 0 it disables the DROOP). The trimmer adjusts the curve slope of the DROOP. On **GCU** it is not necessary to do anything, and indeed, **GCU** does not even know that the DROOP mode has been activated.

DROOP managed by GCU.

If the DROOP should be managed by **GCU**, it should be specifically requested with a digital input configured with DIF.2094 function (for **DST4602x and GC400x**) or DIF.0061 (for **GC500x**). When the input is activated, the DROOP mode is active (if **GCB** is closed).

GCU defines the curve for the voltage DROOP with two values: the working voltage when the generator is without reactive load ("no-load voltage") and the slope of the curve. These two values can be set with **GCU** parameters.

P.0986 parameter allows defining the "no-load voltage" (Vac), i.e. the working voltage when the generator is without reactive load. This parameter can be modified on **GCU** even when the engine is running. All **GCUs** allow the modification of this parameter (when the DROOP mode is active) directly from the display page that shows the single-line system diagram. As an alternative to this parameter, it is possible to use an analogue input to acquire the value of "no-load voltage". In this case the "no-load voltage" will no longer be adjustable by the **GCU** panel (P.0986 is ignored), but it will anyway be displayed:

- **DST4602x**.
    - Obsolete. Configure the desired analogue input with AIF.2402 function. In this way, the conversion of the value acquired by the analogue input in "no-load voltage" is performed with P.0984 and P.0985 parameters. The "no-load voltage" for the DROOP will be set up in P.0984 when the analogue input is at its minimum value (0%); it will be configured with P.0985 when the analogue input is at its maximum (100%). By setting P.0984 to a value higher than P.0985 a reverse scaling will be achieved (when the measure acquired by the analogue input increases, the "no-load frequency" decreases).
    - **Suggested**. Configure the desired analogue input with AIF.2403 function. In this way, the conversion of the value acquired by the analogue input in "no-load frequency" is performed via a conversion curve (see technical manual).
- **GC400x.**

    Configure the analogue input with the AIF.2403 function. In this way, the conversion of the value acquired by the analogue input in “no-voltage” is carried out by means of a conversion curve (see technical manual).

- **GC500x**.
    - **Obsolete** It is necessary to select an analogue input through P.0983 parameter (any value other than "0" and "7"). In this case, there is no need to configure anything in the parameters related to the selected analogue input, and P.0984 and P.0985 parameters are used for scaling the analogue input. See description above for **DST4602x**.
    - **Suggested.** Setting the value "7" in P.0983 parameter. In this case it is necessary to configure the analogue input with the desired AIF.2405 function (see description above for **DST4602x**).

GCU allows setting the slope of the voltage DROOP curve with P.0987 parameter (%). It indicates the percentage drop of voltage (compared to nominal P.0102) when the machine is operating at inductive power factor 0.80.

To use the DROOP voltage, it is necessary to always enable its PI regulator. The parameters that configure the PI regulator for voltage DROOP are P.0989 and P.0990. By setting them both to zero the PI regulator will be disabled. See 4 for the adjustment of the two parameters.

As a rule, the DROOP is used for the parallel with the generators controlled by non **SICES Srl** devices. It is not used for the parallel with mains. As a rule, therefore, the GCU working in DROOP does not know it is in parallel with something else: therefore, it cannot manage the loading and unloading phase in the stages of entry into and exit from parallel. If however **GCU** knows it is in parallel with something else (for example, if it is used in DROOP also in parallel with mains), then it can manage loading and unloading phases. P.0988 parameter is used to configure loading and unloading phases (Hz/s): it indicates the maximum speed at which **GCU** modifies its internal frequency setpoint.

See notes in 5.3.3

5.3.3 Limits for DROOP.

This feature should only be used when the generator that works in DROOP is definitely working in parallel with mains.

It serves to protect the system from errors in the configuration of the DROOP curves. Let's suppose, for example, that the operator has configured a curve for the frequency DROOP with a no-load frequency of 50 Hz. If this generator is put in parallel, for example, to a turbine, which instead works at 50.5 Hz, the generator tends to be dragged by the turbine (because the DROOP requires 50 Hz without load at most) and in the long run this causes the activation of "reversal of energy" protection. The same applies in the case in which the configured curve goes for example from 54 to 50 Hz and the frequency of the turbine is 49.8 Hz (in this case the activation of the "maximum power" protection is very likely).

The same could happen also with the voltage regulator: in this case the machine could supply with a too low power factor, both in capacitive and in inductive status.

By setting P.0991 parameter to "1", **GCU** acknowledges these conditions and, before any protections are activated, disables the DROOP mode and switches to BASE LOAD mode. In detail:

- For voltage DROOP: **GCU** switches to BASE LOAD (by imposing an imported reactive power corresponding to 70% of P.0321 threshold) if the load is capacitive and the imported reactive power is higher than 80 % of the threshold for the "loss of excitation" protection (P.0321). It comes back to DROOP mode if the load is inductive, or if it is capacitive, but if imported reactive power is lower than 70 % of P.0321 threshold.
- For the frequency DROOP.
    - **GCU** switches to BASE LOAD mode (setpoint 0 kW) if the active power is negative and higher (in absolute terms) than 2% of rated one (P.0125). It comes back to droop MODE when the active power becomes positive.

- GCU switches to BASE LOAD mode (setpoint 100% of P.0125) if the active power is higher than 102% of rated one (P.0125). It come back to DROOP mode when the active power returns below 100 % of rated one.

In case GCU activates this "limitation" mode, it shows a symbol "<" or ">" besides the "no-load frequency" or "no-load voltage" setpoint on the page that shows the single-line system diagram.

5.4 Synchronization

With the generic term synchronization two completely distinct operations are actually indicated:

- The rpm and voltage **regulators control** to make sure that two three-phase voltages have the same frequency, the same amplitude and that are in phase with each other (the maximum voltage peak L1 of a three-phase should be temporally aligned with the maximum voltage peak L1 of the other three-phase system).
- The verification that the difference of voltage, frequency and phase between two three-phase systems are below the configured thresholds and that the sense of rotation of the two three-phase systems is the same (obviously, this has no sense for single-phase systems). The purpose of this test is to activate a ("**synchro-check**") signal that enables the closing of the switch that connects the two voltage three-phase systems.

The final purpose of the synchronization process and the closing of a switch that connects together two voltage three-phase systems, therefore limiting at most the current that circulates in the switch at the time of closing (current that increases when amplitude, frequency or phase difference increase).

The closing of the switch should be anyway prevented if the differences in frequency, amplitude and phase are too high, because damages to the equipment that generates the tensions that are going to be connected (to the generator, for example) could be created.

GCU is able to manage both operations, provided that the two voltage three-phase systems are connected to their two three-phase sensors (see the technical manual for the connections and the configuration of the two three-phase sensors).

But it is also able to work with external devices (called synchronizers): in this case **GCU** is just a medium to send the speed control created by the external synchronizer to the rpm regulator.

Finally, **GCU** is able to leave the control of the rpm regulator to an external synchronizer, but to internally manage the "synchro-check". All this depends on the programming parameters of **GCU**.

GCU is potentially able to manage synchronization for both **GCB** and **MCB** switches.

5.4.1 Digital Output functions

GCU offers the following functions for the digital outputs, related to synchronization:

- DOF.3091 (for **DST4602x and GC400x**). It indicates that the synchronization is in progress for the closing of **GCB**.
- DOF.3092 (for **DST4602x and GC400x**) or DOF.0028 (for **GC500x**). It indicates that the synchronization is in progress for the closing of **MCB**.
- DOF.3093 (for **DST4602x and GC400x**) or DOF.0026 (for **GC500x**). It indicates that the synchronization for the closing of **MCB** or **GCB** is in progress.
- DOF.3094 (for **DST4602x and GC400x**) or DOF.0036 (for **GC500x**). It indicates that the synchronization for the closing of **MCB** or **GCB** is in progress and that in this moment the two voltage three-phase systems are synchronized.

- DOF.0103 (AND/OR logics) with the statutes:
    - ST.097: indicates that the synchronization for the closing of **GCB** is in progress.
    - ST.098: indicates that the synchronization for the closing of **MCB** is in progress.
    - ST.099: indicates that in this moment the two voltage three-phase systems are synchronized (**only for DST4602x and GC400x**).

Some of the previous output functions can be used to supply/enable any external synchronizers.

5.4.2 Presence of voltage on the parallel bars

GCU should verify the presence of voltage on parallel bars (or on users, for systems consisting in a single generator), to decide whether synchronization to close a switch is necessary or not. **GCU** can get this information in two ways:

- By using its own mains/bars sensor. In this case P.0126 parameter should be set to "0" and bar voltages should be connected to **GCU** mains/bars sensor. **GCU** uses a fixed threshold corresponding to 33% of rated voltage (with a hysteresis of 3%): if mains voltages are above this threshold, parallel bars are considered powered.
- It is possible to use a **GCU** digital input, configured with the function (DIF.3102 for **DST4602x and GC400x**, DIF.0050 for **GC500x**). Parallel bars are considered powered if this input **is not active** (the input during running indicates the absence of tension from the bars).

GCU is capable of signalling the presence of voltage on parallel bars with a digital output, configured with DOF.3031 (for **DST4602x**) or DOF.0037 (for **GC500x**) functions. **GCU** activates the output if voltage is present on parallel bars.

It is also possible to configure an output with DOF.0103 function (AND/OR logics) with ST.048 status: the output is activated if the voltage is present on parallel bars.

5.4.3 Synchronization for GCB.

GCU is able to manage synchronization for **GCB** for all kinds of systems with the exception of **SPM** and **SSB** systems. It should be explicitly enabled with P.0854 parameter (value 1 or 3).

To manage synchronization internally for the closing of **GCB**, **GCU** should have voltages on both sides of the switch, i.e. the voltage of the generator and the voltage on the parallel bars. **GCU** has always the voltages of the generator at disposal. If **GCU** mains/bars sensor is used to measure parallel bars voltages (P.0126= 0), **GCU** has the voltages it needs at disposal and it is therefore able to internally manage synchronization.

If, instead, GCU mains/bars sensor is used to measure mains voltages (P.0126 = 1), GCU does not acquire the voltages directly on parallel bars and therefore it "would not be" able to manage synchronization internally. If this situation occurs for a system composed of a single generator (**SSB + SSTP**, or **SPtM**, **SPtM + SSB**), other generators that supply voltage to parallel bars cannot exist. In this case, if **MCB** is closed, mains voltage is the voltage of the parallel bars: **GCU** is then able to internally manage synchronization.

In any case, it is always possible to use an external synchronizer to perform synchronization of **GCB**.

Only for DST4602x and GC400x: if an external synchronizer is used but **GCU** could manage synchronization internally (see above), it is possible to configure **GCU** to use the internal synchro-check in any case, to allow the closing of **GCB** (P.0846 parameter, 1 or 3 values). However, if the use of internal synchro-check is enabled and **GCU** cannot manage it internally, **GCU** activates W273 early warning (inconsistent parameters).

If the internal synchronizer (or even just the internal synchro-check) is used, the control to close the switch is activated only when **GCU** recognizes the "synchronized" condition. In the other cases

(external synchro-check), **GCU** keeps the control to close the switch always active during the whole synchronization: it is up to the external synchronizer (or to any external synchro-check) to provide a contact that indicates the status of "synchronized", which should be used for the actual closing of the switch (in series with the control of the **GCU** for closing the switch).

If **GCB** is "controlled externally" (**only possible if DST4602 and GC400x** P.0854 > = 2), **GCU** cannot know when the external logic wants to close the switch and therefore cannot know when to activate the synchronization procedure. It is therefore necessary the presence of a digital input configured with DIF.1004 function: when this input is active, **GCU** performs the synchronization procedure (if it can).

Use of the internal synchronizer

See 5.4.5.

Use of an external synchronizer

GCU is not able to directly manage the external synchronizers provided with UP/DOWN controls. It is necessary to:

- Use a DIPOT external module produced by **SICES Srl** to convert UP/DOWN controls into an analogue signal, then to be managed as described below.
- **Only for DST4602x**: by using the "Digital Potentiometer" provided by the internal PLC, to convert UP/DOWN controls into an analogue value. This value should be memorized into a virtual analogue input, to be managed as indicated below.

GCU is instead able to manage the external synchronizers that provide an analogue control for the rpm regulator. This control should be connected to a **GCU** analogue input, which will transmit the control received from the external synchronizer to rpm regulator during synchronization. NOTE: GCU allows the acquisition of an external signal (during synchronization) to control the rpm regulator, not to control the voltage regulator.

Configuration to use an external analogue synchronizer:

- **DST4602x**:
  - **Obsolete** Configure the desired analogue input with AIF.2106 function (or AIF.2102 function if the external synchronizer is used both for **GCB** and **MCB**). In this way, the scaling of the value acquired by the analogue input is performed with P.0835 and P.0836 parameters. When the analogue input takes the value configured in P.0835, **GCU** controls the minimum speed for the engine (0%). When it takes the value configured in P.0836, **GCU** controls the maximum speed for the engine (100%). It is possible to set P.0835 to a value higher than P.0836, thus obtaining an "inverse regulation": when the value acquired by the analogue input increases, the speed control for the engine decreases.
  - **Suggested**. Configure the desired analogue input with AIF.2107 function (or AIF.2103 function if the external synchronizer is used both for **GCB** and **MCB**). In this way, the conversion of the value acquired by the analogue input in the speed control for the engine is performed through a conversion curve (see the technical manual).
- **GC400x**.

  Configure the analogue input with the AIF.2107 function (or with the AIF.2103 function if the external synchronizer is used both for GCB and MCB). In this way, the conversion of the value acquired by the analogue input to the engine speed command is carried out through a conversion curve (see technical manual).ù
- **GC500x**.

  It is necessary to select an analogue input through P.0832 parameter (any value other than "0"). In this case, there is no need to configure anything in the parameters related

to the selected analogue input, and P.0835 and P.0836 parameters are used for scaling the analogue input. See description above for **DST4602x**.

It is possible to configure a digital output (see 5.4.1) that activates during synchronization to enable the external synchronizer (or to feed it).

5.4.4 Synchronization for MCB.

GCU is able to manage synchronization for **MCB** for any kinds of systems, with the exception of **SPM**, **SSB**, **SPtM** and **MPtM** systems. It should be expressly enabled with P.0855 (value 1 or 3 for **DST4602 and GC400x**, value 1 or 2 for **GC500/GC500Plus**).

In order to manage synchronization for the closing of **MCB** internally, **GCU** should have voltages on both sides of the switch, i.e. mains voltage and users voltage. **GCU** has a single sensor to acquire them both and therefore in principle it "would not be" able to manage synchronization internally. There is only one case in which **GCU** is able to manage it internally, when all the following conditions are met:

- **GCU** mains/bars sensor acquires mains voltage (P.0126=1).
- The system is composed of a single generator (**SSB + SSTP** or **SPtM + SSB**).

In this case, there may not be other generators that supply voltage to users. If the **GCB** is closed, generator voltage is users' voltage: **GCU** is then able to internally manage synchronization.

In any case, it is always possible to use an external synchronizer to perform the synchronization of **MCB**.

DST4602x and GC400x: if an external synchronizer is used but **GCU** could manage synchronization internally (see above), it is possible to configure **GCU** to use the internal synchro-check in any case, to allow the closing of **MCB** (P.0846 parameter, 2 or 3 values). However, if the use of internal synchro-check is enabled and **GCU** cannot manage it internally, **GCU** activates W273 early warning (inconsistent parameters).

If the internal synchronizer (or even just the internal synchro-check) is used, the control to close the switch is activated only when **GCU** recognizes the "synchronized" condition. In the other cases (external synchro-check), **GCU** keeps the control to close the switch always active during the whole synchronization: it is up to the external synchronizer (or to any external synchro-check) to provide a contact that indicates the status of "synchronized", which should be used for the actual closing of the switch (in series with the control of the **GCU** for closing the switch).

If **MCB** is "controlled externally" (P.0855 >= 2), **GCU** cannot know when the external logic wants to close the switch and therefore cannot know when to activate the synchronization procedure. It is therefore necessary an external request for synchronization:

- If **MCB** is managed by a **MCU**, the request for synchronization and also the controls for rpm and voltage regulators are transmitted by **MCU** to **GCUs** through **PMCB** communication bus. On **GCU** nothing else is required.
- If **MCB** is managed by other devices, the presence of a digital input configured with DIF.1034 (for **DST4602x and GC400x**) or DIF.0052 (for **GC500x**) functions is required: when this input is active, **GCU** performs the synchronization procedure (if it can).

Use of the internal synchronizer

See 5.4.5.

Use of an external synchronizer

See note in the previous paragraph for synchronizers with UP/DOWN controls.

GCU is able to manage the external synchronizers that provide an analogue control for the rpm regulator. This control should be connected to a **GCU** analogue input, which will transmit the control

received from the external synchronizer to rpm regulator during synchronization. NOTE: GCU allows the acquisition of an external signal (during synchronization) to control the rpm regulator, not to control the voltage regulator.

Configuration to use an external analogue synchronizer:

- **DST4602x**:
  - **Obsolete** Configure the desired analogue input with AIF.2104 function. In this way, the scaling of the value acquired by the analogue input is performed with P.0817 and P.0818 parameters. When the analogue input takes the value configured in P.0817, **GCU** controls the minimum speed for the engine (0%). When it takes the value configured in P.0818, **GCU** controls the maximum speed for the engine (100%). It is possible to set P.0817 to a value higher than P.0818, thus obtaining an "inverse regulation": when the value acquired by the analogue input increases, the speed control for the engine decreases. It is also possible to use AIF.2102 function if the external synchronizer is used both for **GCB** and **MCB**; in this case, see description in 5.4.2.
  - **Suggested**. Configure the desired analogue input with AIF.2105 function. In this way, the conversion of the value acquired by the analogue input in the speed control for the engine is performed through a conversion curve (see technical manual). It is also possible to use AIF.2103 function if the external synchronizer is used both for **GCB** and **MCB**; in this case, see description in 5.4.2.
- **GC400x**.

  Configure the analogue input with the AIF.2105 function. In this way, the conversion of the value acquired by the analogue input to the engine speed command is carried out through a conversion curve (see technical manual). It is also possible to use the AIF.2103 function if the external synchronizer is used for both **GCB** and **MCB**; in this case see the description in 5.4.2.
- **GC500x**.

  It is necessary to select an analogue input through P.0833 parameter (any value other than "0"). In this case, there is no need to configure anything in the parameters related to the selected analogue input, and P.0835 and P.0836 parameters are used for scaling the analogue input. See description in 5.4.2.

It is possible to configure a digital output (see 5.4.1) that activates during synchronization to enable the external synchronizer (or to feed it).

5.4.5 Use of the internal synchronizer

Synchronization can be performed both manually and automatically.

- **AUTO**: **GCU** uses PI regulators to bring frequencies and voltages of the two three-phase systems to very close values; then it uses PI regulator for the frequency to bring phase difference to 0°. P.0852 and P.0853 parameters determine the maximum duration of synchronization (the first is used if synchronization is used to close **GCB**, the second for **MCB**). If the time-out expires, **GCU** activates A271 shutdown if synchronization is used for **GCB**, W272 early warning for **MCB** (failure to parallel).
- **MAN**: P.0848 parameter influence the switch closing mode with synchronization:
  - “1 – Yes”. In this case, after a manual closing control, **GCU** activates synchronization exactly as if it were in automatic. PI regulators are working. As soon as **GCU** recognizes the "synchronized" condition, it automatically closes the switch. "Failure to parallel" early warnings are not managed: synchronization may last indefinitely.

- “0 – No”. In this case, after a manual closing control, **GCU** forces the display on the synchronization page and sends frequency and voltage controls to rpm and tension regulators. PI controllers are not active: it is up to the operator to manually adjust (from **GCU** display or via external potentiometers) frequency and voltage to cause the synchronism condition (see 5.1 and **Errore. L'origine riferimento non è stata trovata.**).

  When the two voltage three-phase systems are synchronous, the operator should again send a closing control: if **GCU** sees a "synchronism" condition, it acknowledges the control and closes the switch. "Failure to parallel" early warnings are not managed: synchronization may last indefinitely. To abort a manual synchronization, simply select a display page different from B.02.

P.0849 and P.0850 parameters are the coefficients for PI frequency regulator. P.0868 and P.0869 parameters are the coefficients for PI voltage regulator. See 4.3 for the procedure to calibrate these parameters.

During the synchronization you need to manage the rpm regulator frequency and phase. In the initial phase, GCU adjusts the genset frequency as close as possible to the bar or mains frequency; then, it stops managing the frequency and it starts adjusting the phase difference to zero. During the first phase (frequency regulation), usually the controller does not use the PI regulator, but it adjusts it with approximations: with **GC400x** is possible to enable the PI regulators in this phase too, by using the parameter P.1600.1.

5.4.6 Use of internal synchro-check

This term intends the ability of **GCU** to recognize the situation of "synchronized" between the two voltage three-phase systems. **GCU** provides some parameters to configure this function:

- P.0841: it configures the maximum voltage difference (%) between the two three-phase systems to consider them "synchronized".
- P.0842: it configures the maximum frequency difference (%) between the two three-phase systems to consider them "synchronized".
- P.0843: it configures the maximum phase difference (°) between the two three-phase systems to consider them "synchronized".
- P.0844: This parameter configures time. **GCU** allows the closing of the switch if the three previous conditions occurred consecutively for this time (and if the sense of rotation of the two three-phase systems is the same).

5.4.7 Compensation of known phase shifts between the two three-phase systems.

This description applies only to **DST4602x and GC400x**.

Sometimes on the systems it can happen that, for different reasons, it is not possible to connect directly comparable voltage references to **GCU**. For example, it could happen that a generator has the alternator in low voltage, followed by a step-up transformer; the parallel with mains is performed in medium voltage. In this case, medium voltages may be available from the mains and low voltages from the generator. Any transformer introduces a (albeit minimal) phase shift between voltages at its terminals: if then the transformer performs triangle/star conversion or vice versa, the introduced phase shift may be very high.

GCU is able to correctly carry out synchronization even in a condition like this. In detail:

- With P.0845 parameter it is possible to compensate the (known) phase error introduced by the transformer. **GCU**, in this case, subtracts the value set in P.0845 by measured phase shift, and adjusts generator speed to bring the subtraction result to zero.
- If the nominal voltages of the two generators are different, **GCU** does not work on Vac voltages, but converts then to percentage of rated ones. Then it adjusts generator voltage to ensure that the percentage measures coincide.

5.4.8 Display page for synchronization

See **GCU** technical manuals for the description of the display page dedicated to synchronization.

5.5 Supply in parallel with other generators.

Note: this description does not apply if DROOP mode has been activated.

Note: if a digital input configured with "disable power control" DIF.2095 (for **DST4602x and GC400x**) or DIF.0058 (for **GC500x**) functions is active, the distribution of the active power is disabled and the rpm regulator is controlled as indicated in 5.1.

GCUs manage the distribution of active and reactive power when multiple generators controlled by **GCUs** by **SICES Srl** are in parallel "stand alone" among them. These operations are possible thanks to the information the **GCUs** exchange through **SICES Srl PMCB** network.

Each **GCU** transmits to **PMCB**:

- Its status.
- The supplied active power in kW (ADPs).
- The supplied active power in kvar (RDPs).
- The engine rated power in kW (MDPs).

With this information, each **GCU** is able to calculate:

- The active power required by the load in kW (ADPt, sum of ADPs of **GCUs**).
- The reactive power required by the load in kvar (RDPt, sum of RDPs of **GCUs**).
- The rated power of supplying generators in kW (RDPt, sum of ADPs of **GCUs**).
- Load percentage of generators (DPRt, ADPt on MDPt ratio). This percentage value, calculated on the total of the generators, should be maintained even at a single generator level, in order to have a correct distribution of active power.
- Total load active power/reactive power ratio (LOADt, RDPt on ADPt ratio). This value, calculated on the total of the generators, should be maintained even at a single generator level, in order to have a correct distribution of active power.

Additionally, each **GCU** calculates:

- Its active power setpoint (setpoint kW = MDPs * DPRt).
- Its reactive power setpoint (setpoint kvar = LOADt * ADPs).

GCU therefore uses some PI controllers to make sure that the generator supplies the required active and reactive power:

- P.0871 e P.0872 parameters: configure PI controller for active power (acting on voltage regulator).
- P.0811 e P.0812 parameters: configure PI controller for reactive power (acting on voltage regulator).

For the calibration of the above parameters, see 4.3.

5.5.1 Frequency adjustment

When the generator is in parallel with other generators, GCU normally acts on the rpm regulator to try to make the generator supply the active power calculated as described above. As a rule, therefore, it does not make any control on frequency. It is however necessary to control the frequency; otherwise, albeit slowly, it will tend to derive and deviate from rated value. **SICES GCUs** can use two systems:

5.5.1.1 Method 1

This method can be used on all **GCU**. On **GC400x** check that the parameter P.1600.3 is set at 0.

With this method, **GCU** works in the following way:

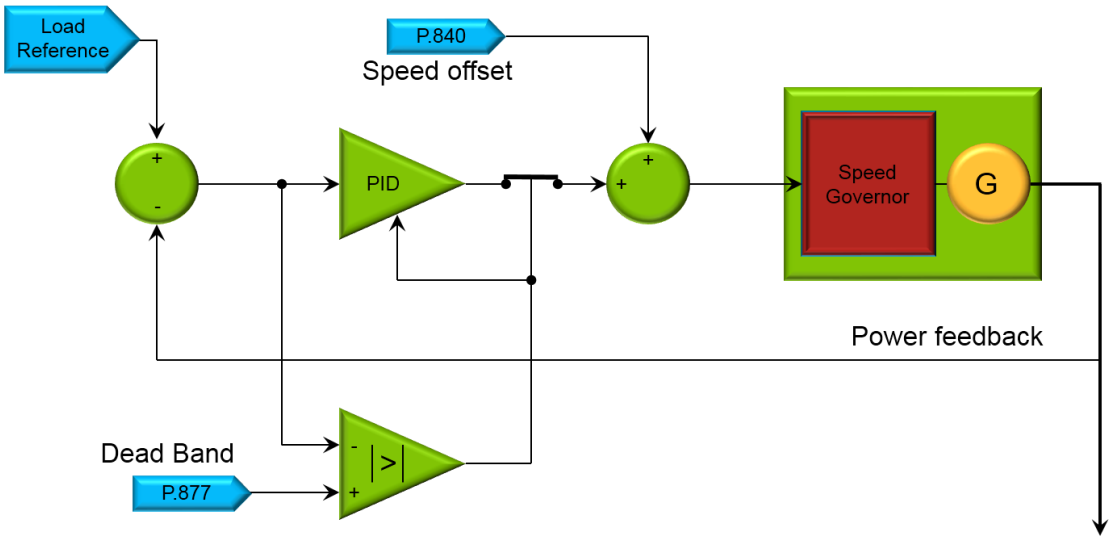
- When the percentage error in the adjustment of active power is higher than a configurable threshold, **GCU** controls the active power.
- When the percentage error in the regulation of active power is lower than the configurable threshold, **GCU** sets the control for the rpm regulator back to the value used outside the parallel, which corresponds to rated frequency or anyway to what as determined with the "fine adjustment" (see 5.1).

The threshold is configurable through P.0877 parameter (% of P.0125) and is called "dead band", because when the control error is lower than it, there is no longer any adjustment, but simply **GCU** requires the nominal frequency to the rpm regulator.

All **GCUs**, in time, continually get in and out the "dead band", thereby ensuring a proper distribution of active power and, at the same time, the keeping of nominal frequency of parallel bars.

By reducing P.0877 value, the probability of entering a "dead band" is reduced: therefore the accuracy of distribution will be increased (because **GCUs** spend more time adjusting power), but it is accepted that transiently the frequency may derive slightly with reference to rated value. Conversely, if the value of P.0877 increases, the precision in adjusting the frequency increases, but a slightly greater error in the distribution of power is allowed. A value of 0.1% for P.0877 is an acceptable compromise.

The following diagram shows the operation:



When a big load (kW) is applied to the parallel bar, the bar frequency tends to decrease: the engines, in fact, tend to slow because they don't manage to increase their power immediately to face the active power load requirement (they need some time). If a big load is removed, the frequency tends to increase temporarily. During these phases, **SICES GCUs** gives higher priority to the frequency regulation more than to the active power regulation. **GCU**, indeed, provides another parameter called "extended dead band" (P.0889 for the active power). This parameter must be configured at a higher value than the one used for the normal dead band: in this way, during the load transfer, **GCU** accepts a higher regulation fault and increases the possibility to enter in "dead band". Consequently, there is an increase also in the time percentage in which **GCU** require the nominal frequency. **GCU** uses the P.0889 parameter instead of P.0877 if the bar frequency differentiates by +/- 0,3 Hz from the nominal.

5.5.1.2 Method 2

This method can be used on GC400x if the parameter P.1600.3 is set at 1.

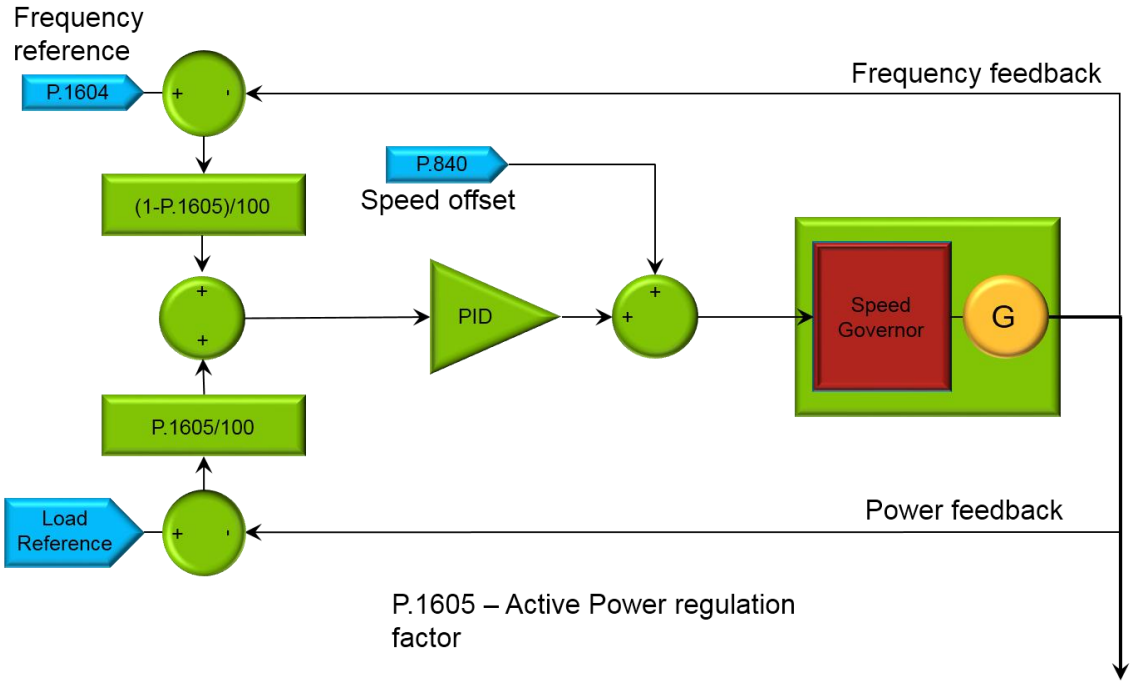
In this case, GCU controls both frequency and active power at the same time. With regard to the management of the active power, refer to the above mentioned. With respect to the management of the frequency, GCU uses the set point P.1604 (see 5.2.1).

The parameter P.1605 establishes if the frequency fault counts more than the active power fault. By default, this parameter is set at 50%: in this way, the active power error equals the frequency one. By increasing the value of P.1605, the active power error weighs more: there will be a better active power sharing and a higher frequency error. Instead, by decreasing the P.1605 value the frequency error weighs more: there will be a better nominal frequency control, in spite of the accuracy on the active power sharing.

When you use this method, GCU ignores the dead band parameters.

Note: as per the following diagram, there is only a regulation PID: the parameters that configure it are P.0871 and P.0872 (P.0977 and P.0978 are not used in this situation).

The following diagram shows the operation:



5.5.2 Voltage adjustment

When the genset is in parallel with other gensets, GCU usually manages the voltage regulator in order to supply the reactive power to the genset, as previously described. Anyhow, it is necessary to check the voltage too; otherwise, even if slowly, this will decrease and move to the nominal value. GCUs can operate in two ways:

5.5.2.1 Method 1

This method can be used on all **GCU**. On **GC400x** check that the parameter P.1650.3 is set at 0.

For the frequency regulation, refer to 5.5.1.1. The parameter that configures the dead band for the reactive power sharing is P.0814 (% of the nominal reactive power):

- When the percentage error in the adjustment of reactive power is higher than P.0814, **GCU** controls the reactive power.
- When the percentage error in the regulation of reactive power is lower than P.0814, **GCU** sets the control for the voltage regulator back to the value used outside the parallel, which corresponds to rated voltage or anyway to what as determined with the "fine adjustment" (see 5.1.2).

When a big load (kW) is applied to the parallel bar, the bar voltage tends to decrease. If a big inductive or capacitive load is removed, the voltage tends to increase temporarily. During these phases, **SICES GCUs** gives higher priority to the voltage regulation more than to the reactive power regulation. **GCU**, indeed, provides another parameter called “extended dead band” (P.0815 for the reactive power). This parameter must be configured at a higher value than the one used for the normal dead band: in this way, during the load transfer, **GCU** accepts a higher regulation fault and increases the possibility to enter in “dead band”. Consequently, there is an increase also in the time percentage in which **GCU** require the nominal voltage. **GCU** uses the P.0815 parameter instead of P.0814 if the bar voltage differentiates by +/- 1% from the nominal.

5.5.2.2 Method 2

This method can be used on GC400x if the parameter P.1650.3 is set at 1.

In this case, GCU controls both voltage and reactive power at the same time. With regard to the management of the reactive power, refer to the above mentioned. With respect to the management of the voltage, GCU uses the set point P.1654 (see 5.2.2).

The parameter P.1655 establishes if the voltage fault counts more than the reactive power fault. By default, this parameter is set at 50%: in this way, the reactive power error equals the voltage one. By increasing the value of P.1655, the reactive power error weighs more: there will be a better reactive power sharing and a higher voltage error. Instead, by decreasing the P.1655 value the voltage error weighs more: there will be a better nominal voltage control, in spite of the accuracy on the reactive power sharing.

When you use this method, GCU ignores the dead band parameters.

Note: there is only a regulation PID: the parameters that configure it are P.0811 and P.0812 (P.0989 and P.0990 are not used in this situation).

Load transients. When a big load is applied (with active and reactive component) to the parallel bar:

- The frequency of the bar tends to decrease transiently: the engines, as a matter of fact, tend to slow down because they cannot instantly increase their power to meet the active power requirement of the load (they need some time).
- The tension of the bar tends to decrease temporarily, because alternators are not able to instantly increase the supplied current to meet the active power requirement of the load (they need some time).

If instead a big load is removed, frequency and voltage tend to increase transiently.

During these phases, **SICES Srl's GCUs** give a higher priority to the adjustment of voltage and frequency, compared to the adjustment of active and reactive power. GCU, as a matter of fact, provides two other parameters known as "extended dead band" (P.0889 for active power and P.0815 for reactive power). These parameters should be set to higher values than those used for the normal dead band: in this way, during transient loading, **GCU** accepts a higher adjustment error and increases the probability of entering the "dead band". Consequently, the percentage of time in which **GCUs** require rated voltage and frequency to the regulators increases.

GCU uses P.0889 parameter instead of P.0877 if bar frequency deviates of +/- 0,3 Hz from rated one. In the same way it uses P.0815 parameter instead of P.0814 if bar tension deviates of +/-1% from rated one.

Loading phases. At the time a generator closes its **GCB** and is in parallel with other generators, it is supplying 0 kW and 0 kvar. From this moment on, it should start to take part of load active and reactive power, up to the condition in which the load is perfectly allocated (in percentage) among all generators. This phase is called "loading phase", and ends exactly at the instant when the load is allocated. With P.0874 parameter (% P.0125/s) it is possible to set the speed at which the generator increases its active power (and consequently also reactive power) during the "loading phase". Conventionally, values around 1%/s are used.

It is possible to configure a digital output of **GCU** with DOF.0103 function (AND/OR logics) with ST.100 status: the output is activated during the "loading phase".

5.5.3 Loading phases

At the time a generator closes its **GCB** and is in parallel with other generators, it is supplying 0 kW and 0 kvar. From this moment on, it should start to take part of load active and reactive power, up to the condition in which the load is perfectly allocated (in percentage) among all generators. This phase is called "loading phase", and ends exactly at the instant when the load is allocated. With P.0874 parameter (% P.0125/s) it is possible to set the speed at which the generator increases its active power (and consequently also reactive power) during the "loading phase". Conventionally, values around 1%/s are used.

It is possible to configure a digital output of **GCU** with DOF.0103 function (AND/OR logics) with ST.100 status: the output is activated during the "loading phase".

5.5.4 Unloading phases

Similarly, when a generator that is supplying in parallel to other generators should open its **GCB**, if there are no active shutdowns or disconnections, **GCU** will transfer all active and reactive power to the other generators before opening the switch: **GCB** will be opened when active power is close to 0. This phase is called "unloading phase", and ends with the opening of **GCB**. **GCU** provides some parameters to configure the "unloading phase":

- P.0874 (% P.0125/s). This parameter is in common with the "loading phase". It determines the speed at which **GCU** transfers active and reactive power to the other generators. It is used if there are no active shutdowns, deactivations and discharges.
- P.0875 (% P.0125/s). This parameter is equivalent to the previous one, but it is used by **GCU** if the generator should come out from the parallel because there are active discharges (but no shutdowns and disconnections).
- P.0878 (%P.0125). This parameter allows configuring active power under which the "unloading phase" is considered as completed and the switch can be opened.
- P.0879 (s). This parameter configures the maximum length of the "unloading phase". After this time the switch is opened irrespectively of the active power of the generator.

It is possible to configure a digital output of **GCU** with DOF.0103 function (AND/OR logics) with ST.101 status: the output is activated during the "unloading phase".

DST4602x and GC400x (not **GC500x**) can use a digital output to report that it is in parallel to another generator. Configure the output with DOF.3095 function.

On all **GCUs**, however, it is possible to configure a digital output with DOF.0103 function (AND/OR logics) with ST.103 status: the output is activated when the generator is in parallel with other generators.

5.5.5 Use of an external load distributor.

It is possible to use an external load distributor to manage the distribution of active power (but not of reactive power) with generators operated by non-**SICES Srl** devices. The analogue control of this device should be connected to an analogue input of **GCU**: **GCU** will transmit the speed variations required by the external load distributor to the rpm regulator.

To use an external load distributor, it is necessary to:

- **DST4602x**:
  - **Obsolete** Configure the desired analogue input with AIF.2108 function. In this way, the scaling of the value acquired by the analogue input is performed with P.0819 and P.0820 parameters. When the analogue input takes the value configured in P.0819, **GCU** controls the minimum speed for the engine (0%). When it takes the value configured in P.0820, , **GCU** controls the maximum speed for the engine (100%). It is possible to set P.0819 to a value higher than P.0820, thus obtaining an "inverse regulation": when the value acquired by the analogue input increases, the speed control for the engine decreases.
  - **Suggested**. Configure the desired analogue input with AIF.2109 function. In this way, the conversion of the value acquired by the analogue input in the speed control for the engine is performed through a conversion curve (see technical manual).
- **GC400x**:
  - Configure the desired analogue input with the function AIF.2109. In this way, the conversion of the value acquired by the analogue input in the speed command for the engine is carried out through a conversion curve (see technical manual).

- **GC500x**:

  It is necessary to select an analogue input through P.0834 parameter (any value other than "0"). It is not necessary to configure anything in the parameters related to the selected analogue input, but P.0835 and P.0836 parameters are uses for scaling the analogue input. When the analogue input takes the value configured in P.0834, **GCU** controls the minimum speed for the engine (0%). When it takes the value configured in P.0835, , **GCU** controls the maximum speed for the engine (100%). It is possible to set P.0835 to a value higher than P.0835, thus obtaining an "inverse regulation": when the value acquired by the analogue input increases, the speed control for the engine decreases.

The external load sharing unit may be turned off/disabled when the generator is not in parallel with other generators. It is therefore necessary to use a digital input to "enable" the use of the signal from the external load sharing unit. Use DIF.2211 function (for **DST4602x and GC400x**) or DIF.0053 function (for **GC500x**): **GCU** uses the signal acquired by the external load sharing unit only if the digital input is active.

Finally, **GCU** uses the signal from the load sharing unit only if it knows it is in parallel with other generators. So, if there are generators controlled by non-**SICES Srl** devices (and of which **GCU** does not know anything), it is at least necessary to use an additional **GCU** digital input to report that at least one of the unknown generators has **GCB** switch closed. When the input is active, **GCU** knows that there is at least another supplying generator and, if it closes its **GCB**, it known it is in parallel. Use DIF.3004 function (for **DST4602x and GC400x**) or DIF.0056 function (for **GC500x**):

5.6 Production in parallel with mains.

GCU controls the modulation of active and reactive powers when the generator is in parallel with mains (if the continuous parallel with mains is allowed). Basically **GCU**, based on performed configuration and on the status of the system, determines a setpoint for active power and a setpoint for reactive power. Then it uses internal PI controllers to make sure that the generator supplies exactly the required active and reactive power:

- P.0871 e P.0872 parameters: configure PI controller for active power (acting on voltage regulator). This PI controller is also common to the load distribution (see 5.5)
- P.0895 e P.0896 parameters: configure PI controller for reactive power (acting on voltage regulator).

For the calibration of the above parameters, see 4.3.

In the following paragraphs the different operating ways, involving different power setpoints, will be described. Remember that the calculated power setpoint may be limited due to anomalous conditions of the mains (see 5.6.3).

During "loading phase" and "unloading phase" phases, **GCU** behaves exactly as described in the chapter dedicated to active/reactive power distribution (see 5.5).

GCU offers two additional parameters when the generator delivers in parallel with mains:

- P.0876 (%P.0125/s). It indicates the maximum percentage variation in active power setpoint per unit of time: it sets a limit to the speed with which **GCU** pursues the calculated setpoint, thus avoiding fast oscillations of the setpoint value. Especially in IMPORT/EXPORT mode, indeed the active power setpoint can change very quickly. The default value for this parameter is 100%/s, which is equivalent to set no limits.
- P.0898 (% P.0125). This parameter identifies the minimum difference (%) between the active power supplied by the generator and the calculated setpoint: below of this difference, **GCU** stops pursuing the calculated setpoint and keeps the rpm regulator control stable. It is used to prevent small oscillations of the active power supplied around the setpoint, due to a non-optimal calibration of the PI controller or to a congenital instability of the system. The default value for this parameter is 0%, which correspond to disabling this function.

On all **GCUs** it is possible to configure a digital output with DOF.0103 function (AND/OR logics) with ST.102 status: the output is activated when the generator is in parallel with mains.

DST4602x and GC400x can use a digital output to report that it is in parallel with mains. Configure the output with DOF.3096 function.

5.6.1 Power factor adjustment

Note: this description does not apply if DROOP mode has been activated.

Note: if there is an active digital input configured with DIF.2095 "disable power control" (for **DST4602x and GC400x**) or DIF.0058 functions (for **GC500x**), the power factor regulator adjustment is disabled and the rpm regulator is controlled as shown in 5.1.

During the supplying in parallel with mains, **GCU** manages a power factor setpoint, not a reactive power setpoint. In this way, the actual reactive power internal setpoint is automatically adapted to supplied active power.

There are three different modes for the management of the setpoint, depending on the value set in P.0880:

- 0: in this case, the continuous parallel with the mains is not allowed.
- 1: BASE LOAD or 2: IMPORT/EXPORT.
- 4: SYSTEM BASE LOAD (only for **DST4602x and GC400x**).

5.6.1.1 BASE LOAD or IMPORT/EXPORT modes

P.0894 parameter allows setting the power factor setpoint. On **GCU** display the parameter can be set as either inductive value (between 0.70i and 1.00i) or as a capacitive value (between 0.90c and 1.00c). However, by setting this parameter (or P.0892 and P.0893 parameters described below) from the serial port, it is necessary to consider the following convention:

- The values lower than or equal to 1 identify an inductive power factor (the value 0.85 means 0.85 inductive).
- Values higher than 1 indentify a capacitive power factor. The value to be set is 2:00 minus the desired setpoint: to select a setpoint of 0.95 capacitive, it is necessary to set 1:05 (2.00 – 0.95).

All **GCUs** allow the modification of this parameter directly on the display page that shows the single-line diagram of the system. As an alternative to this parameter, it is possible to use an analogue input to acquire the setpoint. In this case the setpoint cannot be modified from **GCU** panel (P.0894 is ignored) any more, but it will still be displayed:

- **DST4602x**.
  - Obsolete. Configure the desired analogue input with AIF.2400 function. In this way, the conversion of the value acquired by the analogue input in the power factor setpoint is performed with P.0892 and P.0893 parameters. The "no-load voltage" for the DROOP will be set up in P.0892 when the analogue input is at its minimum value (0%); it will be configured with P.0893 when the analogue input is at its maximum (100%). By setting P.0892 to a value higher than P.0893 a reverse scaling will be achieved (when the value acquired by the analogue input increases, the power factor setpoint decreases).
  - **Suggested**. Configure the desired analogue input with AIF.2401 function. In this way, the conversion of the value acquired by the analogue input in the power factor setpoint is performed by a conversion curve (see technical manual). See the note above regarding the power factor setting format.
- **GC400x**.
  - Configure the desired analogue input with AIF.2401 function. In this way, the conversion of the value acquired by the analogue input in the power factor setpoint is performed by a conversion curve (see technical manual). See the note above regarding the power factor setting format.
- **GC500x**.
  - **Obsolete** It is necessary to select an analogue input through P.0891 parameter (any value other than "0" and "7"). In this case, there is no need to configure anything in the parameters related to the selected analogue input, and P.0892 and P.0893 parameters are used for scaling the analogue input. See description above for **DST4602x**.
  - **Suggested.** Setting the value "7" in P.0891 parameter. In this case it is necessary to configure the analogue input with the desired AIF.2401 function (see description above for **DST4602x**).

GCU does not support the management of power factor external regulators. If it is required to use some, connect them directly to the voltage regulator, and do not use **GCU** control for the voltage regulator.

If **GCU** is "controlled" by a **MCU** board, the power factor setpoint is determined by **MCU**, which shall transmit it to **GCU** through PMCB network.

5.6.1.2 BASE LOAD or IMPORT/EXPORT modes

Note: this description is only suitable for **DST4602x** (starting from rev. 00.48) and for **GC400x**.

Note: this description is not valid with DROOP mode.

Note: if a digital input is configured as “LOCAL BASE LOAD” DIF.2099, the controller works in “BASE LOAD”.

The mode SYSTEM BASE LOAD (also called “steady power”) is similar to the BASE LOAD mode described above. The difference is that the operator selects a reference for the total power factor for all the gensets that compose the power plant.

The management logic is the following:

- It calculates the reactive power value equal to the setpoint for the power factor, according to the total active power supplied by the gensets.
- From this value it is deducted the reactive power supplied by the gensets that are not working in “SYSTEM BASE LOAD” mode.
- A new setpoint for the power factor is calculated starting from the reactive power calculated before and the total active power supplied by the gensets.

The setpoint that results is used by all the gensets that work in “SYSTEM BASE LOAD”. In this way, the total power factor of the genset busbar is always equal to the reference selected by the operator, evene if some gensets work in different modes.

Therefore, this function can work with older **GCU** that don’t support the “SYSTEM BASE LOAD” mode.

The reference for the power factor is unique for the entire plant and it is the same on all **GCU** that work in this mode. It is possible to set this reference in two ways:

- By using the parameter P.0860 (see the previous paragraph). The parameter is automatically shared among all **GCU**. It’s possible to change this parameter by any **GCU**. All **GCU** allow to change this parameter directly on the display that shows the electrical diagram of the plant.
- By using an analogue input configured with the function AIF.2405. The conversion of the value acquired by the analogue input in the setpoint for the power factor is carried out by means of a conversion curve (see technical manual). The analogue signal must be connected to the **GCU** with lower address: in fact, this one converts the signal in a setpoint for the power factor and sends it to the other **GCU**. Anyhow, it is possible (and suggested) to connect the analogue signal to all the controllers: in this way, if the controller with the lower address is broken, the following one takes its place and the system continues to work. The setpoint acquired is displayed on all **GCU** on the page that shows the electrical diagram of the plant.

5.6.2 Active power control

This paragraph defines the logic used by GCU to determine what "mode" should be used to acquire active power setpoint. The different modes are described in the following paragraphs.

It is possible to use an external device (called modulator) to manage power adjustment when the generator is in parallel with mains: same as mentioned 5.5.3 for the external load sharing unit.

P.0880 parameter is the starting point for mode selection:

- 0: in this case the continuous parallel with mains is not allowed.
- 1: BASE LOAD.

- 2: IMPORT/EXPORT.
- 4: SYSTEM BASE LOAD (only for **DST4602x and GC400x**)

The choice made with P.0880 represents a basic choice, but it could be further modified using digital inputs. If these inputs are not all active, P.0880 parameter shall apply.

The following functions to configure the digital inputs affect the selected mode:

- DIF.2099 (for **DST4602x and GC400x**): if this input is active and the parameter P.0880 is set on 4, the selected mode becomes “BASE LOAD”.
- DIF.2092 function (for **DST4602x and GC400x**) or DIF.0077 function (for **GC500x**): if this input is active and P.0880 parameter is set to 1, the selected mode becomes "BASE LOAD - alternative setpoint".
- DIF.2093 function (for **DST4602x and GC400x**) or DIF.0038 function (for **GC500x**): if this input is active and P.0880 parameter is set to 1, the selected mode becomes "IMPORT/EXPORT". **It has higher priority than the input selecting "BASE LOAD - alternative setpoint".**
- DIF.2096 function: if this input is active and P.0880 parameter is different from 0, the selected mode becomes "Transfer to generators". **It has higher priority than the two previous inputs.**

5.6.2.1 BASE LOAD mode.

Note: this description does not apply if DROOP mode has been activated.

Note: if a digital input configured with DIF.2095 "disable power control" function (for **DST4602x and GC400x**) or DIF.0058 function (for **GC500x**) is active, active power modulation is disabled and the rpm regulator is controlled as indicated in 5.1.

BASE LOAD mode (also called "fixed power") is the simplest. **GCU** allows the operator to set an active power setpoint and uses the PI controller to force the generator to provide that power.

P.0884 parameter allows setting the desired active power setpoint. All **GCU** allow the modification of this parameter directly on the display page that shows the single-line diagram of the system. As an alternative to this parameter, it is possible to use an analogue input to acquire the setpoint. In this case the setpoint cannot be modified from **GCU** panel (P.0884 is ignored) any more, but it will still be displayed:

- **DST4602x**.
  - **Obsolete**. Configure the desired analogue input with AIF.2300 function. In this way, the conversion of the value acquired by the analogue input in the active power setpoint is performed with P.0882 and P.0883 parameters. The setpoint will be configured in P.0882 when the analogue input is at its minimum value (0%); it will be the one configured with P.0883 when the analogue input is at its maximum value (100%). By setting P.0882 to a value higher than P.0883 a reverse scaling will be achieved (when the measure acquired by the analogue input increases, the active power setpoint decreases).
  - **Suggested**. Configure the desired analogue input with AIF.2301 function. In this way, the conversion of the value acquired by the analogue input in the active power setpoint is performed through a conversion curve (see technical manual).
- **GC400x**.
  - Configure the desired analogue input with AIF.2301 function. In this way, the conversion of the value acquired by the analogue input in the active power setpoint is performed through a conversion curve (see technical manual).

- **GC500x**.
    - **Obsolete** It is necessary to select an analogue input through P.0881 parameter (any value other than "0" and "7"). In this case, there is no need to configure anything in the parameters related to the selected analogue input, and P.0882 and P.0883 parameters are used for scaling the analogue input. See description above for **DST4602x**.
    - **Suggested.** Setting the value "7" in P.0881 parameter. In this case it is necessary to configure the analogue input with the desired AIF.2301 function (see description above for **DST4602x**).

It is also possible (but not mandatory) to use a **GCU** digital input to decide whether to acquire the setpoint for the BASE LOAD from the analogue input or whether to use P.0884 parameter. Configure the input with DIF.2710 function:

- If the input is active, the setpoint for the BASE LOAD is acquired by the analogue input.
- If the input is not active, the setpoint for the BASE LOAD is P.0884 parameter.

If **GCU** is "controlled" by a **MCU** board, the power setpoint for the BASE LOAD is determined by **MCU**, which shall transmit it to **GCU** through **PMCB** network (see **Errore. L'origine riferimento non è stata trovata.**).

5.6.2.2 BASE LOAD mode – alternative setpoint.

Note: this description does not apply if DROOP mode has been activated.

Note: if a digital input configured with DIF.2095 "disable power control" function (for **DST4602x and GC400x**) or DIF.0058 function (for **GC500x**) is active, active power modulation is disabled and the rpm regulator is controlled as indicated in 5.1.

The same as in the previous paragraph is valid. The difference is that in this mode the active power setpoint is taken from P.0902 parameter All **GCU** allow the modification of this parameter directly on the display page that shows the single-line diagram of the system (when this mode is selected). It is not possible to use the analogue inputs to acquire the alternative setpoint.

5.6.2.3 IMPORT/EXPOR mode T

Note: this description does not apply if DROOP mode has been activated.

Note: if a digital input configured with DIF.2095 "disable power control" function (for **DST4602x and GC400x**) or DIF.0058 function (for **GC500x**) is active, active power modulation is disabled and the rpm regulator is controlled as indicated in 5.1.

In this mode the operator does not directly select the active power setpoint for the generator, but rather selects the power value that should be guaranteed at the interchange point with mains. By convention, negative values for the measurement of power at the interchange point with mains indicate power transferred to mains (exported).

GCU should however acquire the power measurement at the interchange point with mains. Once this power is known, and the actual power delivered by the generator is known, too, **GCU** is able to calculate the power that should be supplied by the generator to make sure that in the interchange point with mains there is the required power. This even if the local load (users) is very variable.

GCU offers P.088 parameter (kW) to set the power setpoint on the interchange point with mains (negative if the power of the system should be exported to mains). It is not possible to use the analogue inputs to acquire this setpoint.

To acquire the power measurement at the interchange point with mains, on the other hand, there are three possibilities.

- Use an external tool to measure power and connect the instrument to an analogue input of **GCU**. In this case:

- **DST4602x**.
    - Obsolete. Configure the desired analogue input with AIF.2302 function. In this way, the conversion of the value acquired by the analogue input in the power measurement on the mains is performed with P.0886 and P.0887 parameters (kW). The measurement will be the one configured in P.0886 when the analogue input is at its minimum value (0 %); it will be configured with P.0887 when the analogue input is at its maximum value (100%). **NOTE: power measurement on the mains should be managed with its sign (negative, if exported): consequently, one of the two parameters should be set to a negative value.**
    - **Suggested**. Configure the desired analogue input with AIF.2303 function. In this way, the conversion of the value acquired by the analogue input in power measurement on the mains is performed through a conversion curve (see technical manual). **NOTE: power measurement on the mains should be managed with its sign (negative, if exported): consequently, one point of the curve should be negative.**
- **GC400x**.
    - Configure the desired analogue input with AIF.2303 function. In this way, the conversion of the value acquired by the analogue input in power measurement on the mains is performed through a conversion curve (see technical manual). **NOTE: power measurement on the mains should be managed with its sign (negative, if exported): consequently, one point of the curve should be negative.**
- **GC500x**.
    - **Obsolete** It is necessary to select an analogue input through P.0885 parameter (any value other than "0" and "7"). In this case, there is no need to configure anything in the parameters related to the selected analogue input, and P.0886 and P.0887 parameters are used for scaling the analogue input. See description above for **DST4602x**.
    - **Suggested.** Setting the value "7" in P.0885 parameter. In this case it is necessary to configure the analogue input with the desired AIF.2303 function (see description above for **DST4602x**).

- Use **GCU** fourth amperometric transformer to measure active power of a phase of the mains. To do this, it is necessary that **GCU** mains/bars sensor is used for the measurement of the mains (P.0126=1). Moreover, it is necessary to perform the following configurations:
    - P.0130=2: indicates that the fourth amperometric transformer is connected to L1 phase of mains.
    - P.0131=4: indicates that the power measurement acquired by the fourth amperometric transformer is used to calculate active power on phase L1 of mains.

  GCU then calculates the power on phase L1 of mains and, for three-phase systems, multiplies it by 3, therefore assuming that users are evenly distributed over the three phases. If it is not the case, it is possible set a correction factor by using P.0132 parameter: through this factor it is possible to increase (if> 1) or decrease (if <1) the value calculated by **GCU** to make it as close as possible to actual measure.

- Power measurement on the interchange point with mains can be performed by a **MCU**: in this case the measurement is transferred to **GCUs** through **PMCB** network.

The actual power setpoints for the generator therefore varies depending on the power absorbed by local users. It may happen, therefore, that the required power is very low: the generators are not designed to work long hours with low power and so this is a situation that should be avoided. **GCU** offers P.0904 parameter that allows setting a minimum power value the generator should supply, regardless of the requirements of the power setpoint on the interchange point with mains. In short, if

the power required for the generator is lower than P.0904, the generator anyway supplies what specified in P.0904, although this could mean an unwanted power export to mains.

5.6.2.4 SYSTEM BASE LOAD mode

Note: this description is only suitable for **DST4602x** (starting from rev. 00.48) and for **GC400x**.

Note: this description is not valid with DROOP mode.

Note: if a digital input is configured with the function DIF.2095 “power control desabled”, the adjustment of the active power is disabled and the round regulator is commanded as indicated in 5.1.

Note: if a digital input is configured as “LOCAL BASE LOAD” DIF.2099, the controller works in “BASE LOAD”.

The mode SYSTEM BASE LOAD (also called “steady power”) is similar to the BASE LOAD mode described above. The difference is that the operator selects a reference for the total power factor for all the gensets that compose the power plant.

Starting from the reference set by the operator, the active power supplied is deducted by the gensets that are not working in “SYSTEM BASE LOAD”. The setpoint that results is divided (in percentage) among all the gensets that work in “SYSTEM BASE LOAD”. In this way, the active power exported in the mains is always equal to the reference selected by the operator, even if some gensets work in different modes.

Therefore, this function can work with older **GCU** that don’t support the “SYSTEM BASE LOAD” mode.

Note: the logics for the management of the load (see 8.6) can command the controllers that work in “SYSTEM BASE LOAD” mode: the **GCU** can autonomously start/stop the gensets in order to make the system produce the active power desired, keeping the gensets at an acceptable power level (stopping some of them if the power is too low, or starting some of them if it’s too high).

The reference for the power factor is unique for the entire plant and it is the same on all **GCU** that work in this mode. It is possible to set this reference in two ways:

- By using the parameter P.0858 (kW). The parameter is automatically shared among all **GCU**. It’s possible to change this parameter by any **GCU**. All **GCU** allow to change this parameter directly on the display that shows the electrical diagram of the plant.
- By using an analogue input configured with the function AIF.2307. The conversion of the value acquired by the analogue input in the setpoint for the power factor is carried out by means of a conversion curve (see technical manual). The analogue signal must be connected to the **GCU** with lower address: in fact, this one converts the signal in a setpoint for the power factor and sends it to the other **GCU**. Anyhow, it is possible (and suggested) to connect the analogue signal to all the controllers: in this way, if the controller with the lower address is broken, the following one takes its place and the system continues to work. The setpoint acquired is displayed on all **GCU** on the page that shows the electrical diagram of the plant.

5.6.2.5 "Transfer to generators" mode

The purpose of this mode is to gradually transfer the power absorbed by the load from mains to generators and then open **MCB** switch, thus leaving the load entirely supplied by generators.

To fully use this functionality, the underlying mode (the one that would be selected if the input forcing the "transfer to the generators" wouldn't be active) should be "IMPORT/EXPORT". In this way, **GCU** makes sure that the power on the interchange point with mains is the one determined with the related setpoint, then it opens **MCB** switch (the power setpoint on the interchange point with mains should be zero to avoid load transients on the generator as far as possible).

If the power measurement on mains is not available, it is not possible to use "IMPORT/EXPORT" mode. So the underlying mode will be "BASE LOAD" or "BASE LOAD - alternative setpoint". GCU makes sure that the generator supplies the power selected with the related setpoints, then opens

MCB switch (the power setpoint should be set at a value as much as possible very close to the one of the load to avoid load transients on the generator).

If the digital input requiring "transfer to generators" mode deactivates, **GCU** shall put the generator in parallel with mains.

5.6.3 Automatic reduction of power due to anomalies on mains

The recent European standards governing the parallel with mains require that in the event of non-serious malfunctions on mains, the generator is not disconnected to it but rather, it should help in maintaining mains frequency and voltage at acceptable values. For now **only for DST4602x** is able to act on **DST4602x** active power setpoint (by limiting it, as required by standards) to avoid disconnecting the generator from mains.

The rest of the chapter is concerning, for now, **only DST4602x**.

When power limitation has been activated, **DST4602** displays a message on the bottom line of the display. In addition, the power setpoint on M.01 page flashes to indicate that a limitation is active.

NOTE: the limitation in principle should be applied to the power exported to mains. It coincides with the one supplied by the generator for pure production systems. The two powers might be different if there were any local loads. For the sake of simplicity, **GCU** applies the limitation always and only to the power supplied by the generator, because systems that also provide for the emergency (for example, hospitals) should be able to be isolated from mains for stricter voltage/frequency thresholds (to protect loads) and therefore they should not be involved by power limitation. At any rate, nothing prevents that in the future we can complicate this management to create a real limitation on the power exported to mains (in this case, however, **DST4602x** should get power measure on the interchange point with mains).

5.6.3.1 Reduction of the power supplied by mains high frequency

The standards provide for a limitation on the power exported to mains when frequency on the same mains increases. As a matter of fact, if mains frequency increases, it means that there is a production surplus and therefore it is necessary to reduce production.

Until mains frequency is lower than P.0951 threshold (percentage of P.0105), the power supplied by the generator should not be limited. When mains frequency exceeds this threshold consecutively for P.0952 seconds, **GCU** should:

- Memorize the power that the generator was supplying at that time (this power value is referred to as "initial power" below).
- Activate the limiting phase.

While the limiting phase is active, **DST4602x** should continually calculate the generator power setpoint by subtracting a value proportional to increase of mains frequency from the "initial power".

P.0953 parameter determines the quantity which should be subtracted from the "initial power" for each Hz of mains frequency increase with reference to P.0951 threshold. The parameter is expressed as %/Hz: the percentage, however, does not refer to the rated power of the generator, but to initial power.

The reduction works on the maximum frequency reached by mains while the limiting phase is active: if the frequency rises to 50.5Hz, but then drops to 50.3 Hz, the reduction percentage is always calculated with reference to the value 50.5. The standard, as a matter of fact, require that the power supplied by the generator can never be increased (but only reduced) until mains frequency comes back to acceptable values.

The limiting phase ends when mains frequency is steadily included between P.0905 and P.0906 thresholds (see 3.2.1) for the time configured in P.0903.

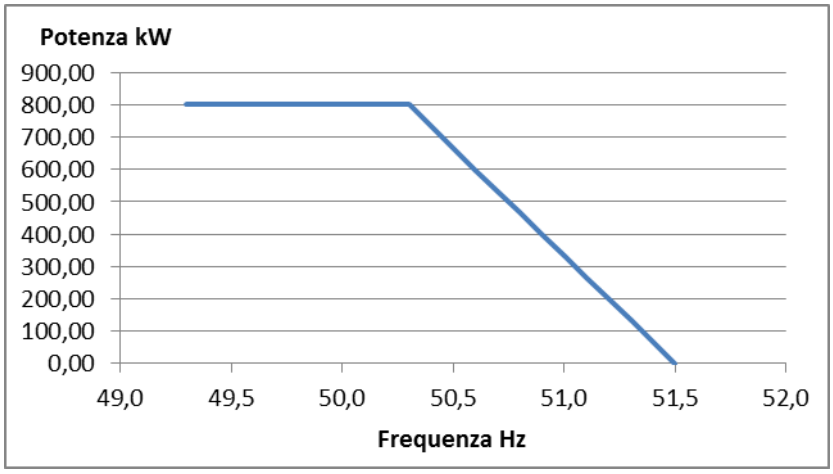
DST4602x records EVT.1121 event every time this limitation is activated, and EVT.1122 event each time it is deactivated.

Example of use.

Parameter	Description	Value
P.0951	Mains high-frequency threshold for the limitation of active power setpoint.	100.6 % (50.3 Hz)
P.0952	Delay for active power setpoint limitation for mains high frequency.	1.0 s
P.0953	Active power setpoint limitation ratio for mains high frequency.	83.3 %/Hz

Let's suppose to use a 1000 kW generator in parallel with mains. The generator supplies 800 kW, mains frequency is 50 Hz.

Mains frequency begins to rise. When it exceeds 50.3 Hz for 1.0 seconds, **DST4602x** memorizes internally the supplied power at that time (800 kW) and starts to apply the limitation according to the following chart.



Let's suppose that frequency rises to 51.0 Hz. Power will be limited to about 320 kW. Should then frequency come back to 50.5 Hz, power will not be limited to about 670 kW, but it will remain at the minimum reached value (320 kW in this example). The limitation will be removed (and thus the generator will supply 800 kW again) only when frequency returns come back between P.0905 and P.0906 thresholds for P.0903 time.

5.6.3.2 Reduction of the power supplied due to mains low-frequency

Under the new standards, the generator should stay in parallel with mains even with frequencies lower than the rated one, up to 47.5 Hz. In these conditions there are two effects:

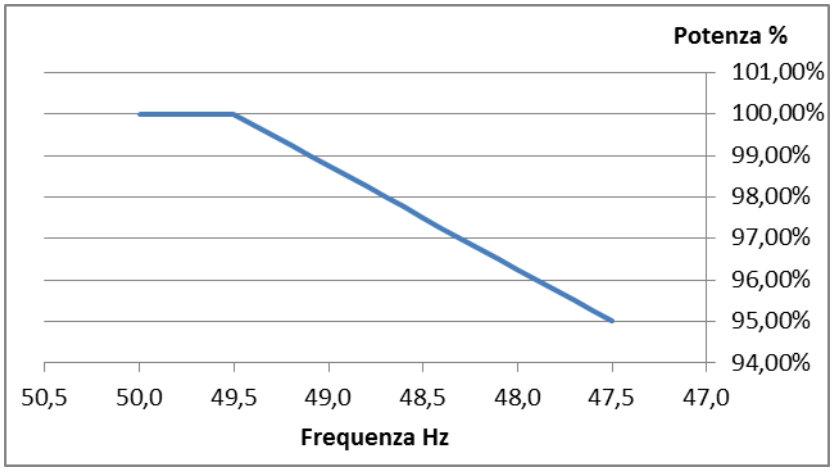
- By considering that the engine has a constant torque above 45 Hz, there is still a decrease in the maximum power that could be supplied (power = torque x rpm). Therefore, the maximum power that can be supplied by the engine decreases when rounds decrease (and thus when frequency decreases).
- When frequency decreases, the voltage regulator would attempt to lower voltage according to its Hz/V curve. As it is in parallel with mains, this results in a power factor which tends switch to capacitive: GCU compensates this drop by requiring more voltage to voltage regulator. At any rate, the alternator manufacturers (Marelli) say that when frequency decreases, the current supply capacity of the alternator is reduced by about 5% (due to thermal issues).

To handle this situation, **DST4602x** provides for the following parameters:

- P.0956: mains low frequency threshold for active power setpoint limitation (%).
- P.0957: delay for active power setpoint limitation for mains low frequency (s). The limitation is applied if frequency is below P.0956 threshold for P.0957 time. Power limitation is immediately removed if frequency rises above P.0956 threshold.
- P.0958 : active power setpoint limitation ratio for mains low frequency. (%/Hz).

DST4602x records EVT.1127 and EVT.1128 events when it enables/disables this limitation.

By assuming to set P.0956= 99.0 % (49.5Hz), if P.0957=3.0 s and P.0958=2.5%/Hz, the following power reduction curve for low frequency is achieved:



5.6.3.3 Reduction of supplied power due to mains low voltage

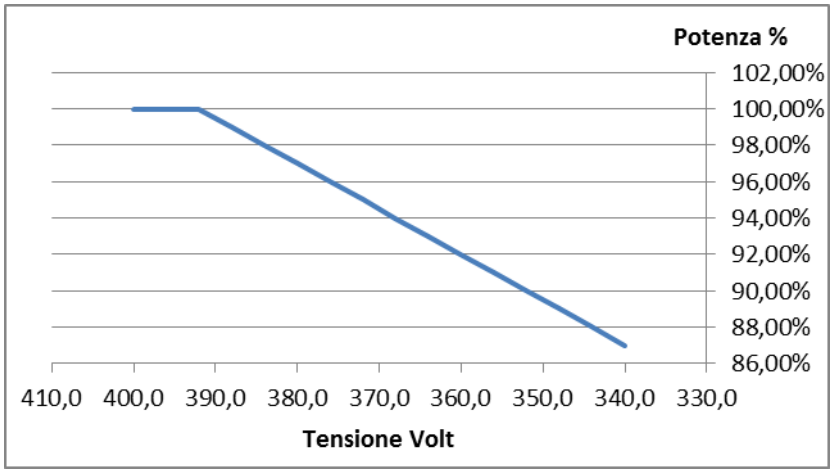
Under the new standards, the generator should stay in parallel to mains with voltages up to 85% of rated voltage. In this case, the engine has no problems, but it is anyway necessary to limit the current supplied by the alternator (Marelli says between 8 and 15%, depending on the alternator). In fact, when mains voltage decreases, given the same supplied current, the supplied power decreases, too. To try to maintain the same power, currents should be increased, but at the risk of overcoming the limits of the alternator.

To manage this situation, **DST4602x** manages these new parameters:

- P.0959: mains low-voltage threshold for active power setpoint limitation (% of rated one).
- P.0960: delay for active power setpoint limitation for mains low voltage (s). Voltage limitation applies if average mains voltage stays under P.0959 threshold for P.0960 time. Power limitation is immediately removed if the average voltage of the generator rises back above P.0959 threshold.
- P.0967: power limitation ratio (% power for 1% of voltage). Set this parameter to 2% means a limitation of 2% with reference to nominal power for a voltage drop of 1% of rated voltage with reference to P.0959 threshold.

DST4602x records EVT.1129 and EVT.1130 events when it enables/disables this limitation.

By assuming to set P.0959=98.0% (392V), P.0960=3.0 s and P.0967=1, the following power-reduction curve due to low voltage will be achieved:



5.6.3.4 Supplied power reduction required by contact

Some European standards (the German one, for example) require the possibility, by the network operator, to control the reduction of the power exported by the generator through contacts. The standards requires four contacts, which should correspond to 100% , 60%, 30% and 0% of the rated power of the generator.

The first contact (100%) can be managed as "in absence of the other three"; alternatively, it can be managed on **DST4602x** by configuring a digital input as "**BASE LOAD** - Alternative setpoint" (see 5.6.2).

DST4602 manages the 4th contact (which requires the supplying of 0% of rated power) by configuring a digital input as "inhibition to power loading" (see 2.1).

For the remaining two contacts, **DST4602x** provides for two functions for the configuration of the digital inputs (DIF.2097 and DIF.2098). The activation of these inputs involves the limitation of the power supplied to the one set by P.0954 and P.0955 parameters (both expressed as percentage of the P.0105 rated power).

The limitation is immediately removed when the digital inputs become "non-active".

5.6.3.5 Stopping of the engine for excessive reduction of supplied power

As seen above, the power setpoint that the generator should supply when working in parallel with mains may be limited by many conditions. It may happen that this setpoint is limited to a very low value (for example, 10% of rated power). The generator cannot provide so low powers for a long time (because it will be damaged). It is therefore possible to set a power threshold and a delay to stop the engine under this condition:

- P.0968: threshold to stop the engine due to excessive limitation of active power setpoint (%).
- P.0969: delay to stop the engine due to excessive limitation of active power setpoint (s).

The function is disabled by setting one or both the previous parameters to zero (and thus the engine will never be arrested by this function). The engine is stopped only if it is supplying in parallel to mains and if the power setpoint is below P.0968 threshold due to one of the limitations described above, consecutively for P.0969 time. The engine will be restarted when the power setpoints is no longer be limited to a value below P.0968 threshold.

When the engine is stopped due to this function, an event is recorded in the archive (EVT.1131) and a description appears on the bottom line of the display, as well as on the status page S.01. When the engine is restarted because the power setpoint is no longer limited, an event will be recorded in the archives (EVT.1132).

Note: power setpoint limitations are active even if **DST4602x** does not measure mains frequency and voltage. During the parallel with mains, in fact, generator voltage and frequency are equal to those of mains and then **DST4602x** is able to apply the limitations on the base of generator voltage and frequency. This function, however, needs to measure mains frequency and voltage after the engine has been stopped, to allow its re-starting. If **DST4602x** does not measure mains frequency and voltage, this function stops the engine if the power setpoint is limited by mains frequency or voltage, but only if it is limited by a contact.

6. Neutral earthing remote-control switch

This term identifies the remote-control switch (or anyway the switch) that connects the generator neutral line to protective earthing. It is not the remote-control switch used to connect the generator neutral to parallel bars and/or users.

SICES Srl uses the acronym **NECB** (Neutral-Earth Circuit Breaker) to indicate this remote-control switch.

The currently implemented management for NECB contactor replaces a previous version, that was oversimplified. In detail:

- **DST4602x**: simplified management until the review 00.39. Complete management of the review 00.40.
- **GC400x**: complete management only.
- **GC500x**: simplified management until the review 01.29. Complete management starting from review 01.30.

DST4602x and GC400x provide for DOF.2061 function to configure a digital output to control NECB remote-control switch: **GC500x** supply DOF.0033 function to configure a digital output for NECB contactor control. **GCU** enables the output to close the remote-control switch.

GCU puts DIF.3005 function at disposal to configure a digital output to get the feedback of the contactor: **GCU** considers that the remote-control switch is closed when this input is active.

6.1 Simplified management

With the simplified management, the contactor is always closed with the engine in motion, when generator voltage and frequency are within tolerance. It is immediately opened when the generator is in parallel with mains and is immediately closed as soon as the parallel with mains ends. Since, as a rule, the generator voltage is used to excite NECB remote-control switch coil, **GCU** controls the opening of NECB at the beginning of the stopping cycle, to prevent the remote-control switch from "trill" when the generator voltage starts to decrease.

6.2 Complete management

The complete management also controls parallel among generators: when more generators are in parallel among them (stand alone), the neutral of the parallel bar should be earthed in a single point. Moreover, also early warnings of failure to open and failure to close the remote-control switch are now managed.

It is not essential to acquire feedback from the remote-control switch, but if acquired, **GCU** uses it to:

- Activate W204 (failure to close NECB) and W205 (failure to open NECB) early warnings. In this case, the delay associated with the selected digital input is used as a time-out to activate the early warnings.
- During "stand-alone" parallel between multiple generators, **GCU** uses the two previous early warnings to make sure that there is always and only a generator with NECB remote-control switch closed.

Finally, **GCU** provides for P.0159 parameter to define the type of management for NECB remote-control switch:

- 0: a remote-control switch for each generator (which provides the neutral earthing of the generator).
- 1: a single remote control switch for parallel bars (which provides the neutral earthing of the bar).

6.2.1 A single remote-control switch on parallel bars

This management mode provides for a single NECB remote-control switch that connects the parallel bars neutral to the earth. In this case:

- NECB remote-control switch closing controls of individual **GCUs** should be connected in parallel (so that the remote-control switch closes as soon as a **GCU** controls its closing).
- If the feedback of NECB remote-control switch (recommended) should be used, it should be connected to all **GCUs** (use separation diodes, refer to **GCU** technical manual for the parallel connection of digital inputs).

For this management method, as there is only a remote-control switch, **GCUs** should not have to decide which of them should control the closing of the remote-control switch: simply all **GCUs** with closed **GCB** order the closing of NECB remote-control switch, **unless the parallel bar of the generators is not connected to mains.** In fact, all **GCUs** with **GCB** closed, immediately control remote-control switch opening as soon as they find to be in parallel with mains; all of them immediately request their closing as soon as the parallel phase with mains is finished.

GCU supposes that the voltage of parallel bars is used to excite the coil of NECB remote-control switch. So it doesn't manage any early warning for the failed closing of the remote control switch if no **GCB** is closed (bars aren't supplied). Anyway, the **GCU** that first closes its own **GCB** (and therefore gives tension to the parallel bars) controls the closing of NECB remote-control switch an instant before the closing of **GCB** switch: in this way, if the system utilizes a subsidiary voltage to excite the coil of NECB (present also with all open **GCBs**), NECB will be already closed when the first **GCB** closes (avoiding in this way to leave neutral floating even for just a moment).

Failed opening and closing of NECB remote-control switch should be managed at system level:

- If all **GCUs** control remote-control switch opening and it remains closed for the period of time connected with the input that gets the feedback, all **GCUs** will activate the failed opening early warning (W205).
- If at least a **GCU** controls the closing of NECB remote-control switch, and there is at least one **GCB** closed, but the remote-control switch is open for the time connected with the input the gets the feedback, **GCUs** that have controlled the closing will trigger the failed opening early warning (W204).

6.2.2 One remote-control switch for each generator

This management mode provides for each generator to have its own NECB remote-control switch. This management is more complicated, but is the only one that can be applied in case of modular generators (containers).

GCU presupposes that the generator voltage is used to excite NECB remote-control switch. For this reason, it is necessary that the remote-control switch is closed only when generator voltage is within tolerance (otherwise the remote control switch trills): accordingly, the remote-control switch will be opened during the starting and stopping phase of the generator. In these phases, **GCB** is open and therefore the opening of NECB remote control-switch doesn't affect on the earthing of the rest of the system, but it could create problems of measure to **GCU** (it is tolerated because it is a temporary situation).

GCU controls the opening of the remote-control switch in the following situations:

- When **GCB** is open:
  - If the engine is idle.
  - If the engine is in action but the generator voltages are out of tolerance.
- When **GCB** is closed:
  - If the generator is in parallel with mains (both **MCB** and **MGCB** switches closed).

- If the generator isn't in parallel with mains (**MCB** and/or **MGCB** switches open), but is in parallel with another generator that is more entitled than it to close its own NECB remote-control switch, but only if this generator has NECB remote-control switch closed.

In all other cases **GCU** controls to close the remote-control switch.

In particular, talking about parallel among generators (not about parallel with mains), a single **GCU** at a time (among those with **GCB** closed) has to close its own NECB. Usually is **GCU** that controls the largest generator among those with **GCB** closed (in case there are two or more generators with the same nominal power, the one with the lower address should be considered - P.0452).

If the feedback of NECB remote-control switch is connected (heartily advised in case of parallel among generators), **GCU** will always manage early warnings for failed opening/closing of the remote-control switch. In the logic for selecting the **GCU** that has to close NECB remote-control switch, these early warning should be taken into account. In detail:

- If a GCU indicates (on the PMCB Can Bus) the "failure to close" its own remote-control switch (or the impossibility to close it, for example in case of an active shutdown), it should be excluded from the list of candidates for the control of closing.
- If a **GCU** (with **GCB** closed) indicates (on the **PMCB** Can Bus) the " failure to close " its own remote-control switch, it will be automatically selected to be the only one intended to close of its own remote-control switch. When the operator "recognizes and stops" the early warning, then, the most suitable **GCU** for the closing of the remote-control switch will be newly selected.

7. Closing before excitation (CBE)

This function is available **only for DST4602x.**

This acronym identifies the "fast parallel" function of **DST4602x**. From a conceptual point of view, it consists in closing **GCB** switches of all generators that have to be connected in parallel, even before starting engines (so on the parallel bar without tension). Then engines are started by removing the control for excitation to alternator: when all engines have reached their speed, excitation for all alternators is activated at the same time: the loading phase intrinsically present in voltage regulators allows alternators to synchronize before voltage reaches the nominal value.

This function is optional: it should be activated by means of an option code. The option code has to be requested to **SICES SRL** by supplying **DST4602x** ID code (hexadecimal code with 12 figures that can be seen at page S.03 of the display and indicated on the back of **DST4602x**). Once received the option code from **SICES SRL**, it should be entered in P.0006 parameter to enable CBE function. Refer to the page “S.03” of the display at the item "Code for options" to verify whether the function is active or not:

- 00: no option
- 01: fast parallel

CBE function is anyway disabled (on a **DST4602x**) if:

- **DST4602x** doesn't acquire the rotation speed of engine.
- **DST4602x** doesn't acquire the status of GCB switch.
- **DST4602x** doesn't acquire (in any way) the status of presence /absence of tension on parallel bars.
- **DST4602x** is in MAN or TEST mode.
- Other **GCUs** that don't support CBE function are connected to **PMCB** network (**GC500x**, **GC400x**, **DST4601x**).
- There is tension on parallel bars before the closing of **GCB** switches.
- Some **GCUs** indicate on the **PMCB** network the status of “**GCB** not open”.

Moreover, to use CBE function, it is necessary to configure a digital input with DIF.2707 function (“Closing enabling before of excitement”): CBE function will be enabled only when the input is active.

Moreover it's necessary to configure a digital output through DOF.2201 function (“Alternator electric discharge control”). If no output is configured in this way, CBE function will be disabled. NB: the output will be always idle except during the first phase of the fast parallel. In fact the working output discharges excitement from alternator.

CBE function is configured with the following parameters:

- P.0259 (“time-limit for starting”) and P.0260 (“minimum speed for starting”). These two parameters are used to exclude, from CBE function, the generators that aren't immediately started (**GCUs** of these generators will open **GCB** switch and will go on with the usual parallel sequence through synchronization). Generators that don't reach the minimum rotation speed indicated in P.0260 within P.0259 seconds from the starting request will be excluded by CBE function.
- P.0261 (“time-limit for excitation control”) and P.0262 (“minimum speed for excitation control”). This two parameters are used to exclude from CBE function the generators that, even if started, don't reach very quickly the minimum rotation speed required to activate

excitation to alternators (the **GCUs** of these generators will open **GCB** switch and will go on with the parallel sequence through synchronization). Generators that don't reach the minimum rotation speed indicated in P.0262 within P.0261 seconds from the starting request will be excluded by CBE function.

- P.0263 (“stabilization time”). This parameter configures a delay from the time all generators exceed the minimum rotation speed specified with P.0262 before activating the alternators. Usually this time should be left on zero, to reach parallel as quickly as possible. If it is necessary to let engine stabilize before activating excitation to alternators, set here a delay (in this case also P.0264 parameter should be set on 1).

- P.0264 (“enabling of reduced speed”). By setting this control on “1”, **GCUs** require reduced speed to the rpm regulators until the time when the excitation to alternators is activated. It is used to activate excitation when all engines run at the same speed. But, by setting P.0264 on “1”, a delay in the total time for parallel is introduced: we could note empirically that CBE function works well also leaving P.0264 on zero, above all if the engines involved in parallel are equal among them.

8. PMCB communication digital bus

The **GCUs** produced by **SICES SRL** (but **MCU** and **BTBCU**, too) communicate among them by using a Can Bus line called **PMCB** (“Power Management Communication Bus”).

This bus is not always needed (for systems composed of a single generator it isn't used). Therefore, **GCU** supplies the parameter P.0800 to enable/disable this Can Bus line. Possible values are:

- 0: **PMCB** disabled.
- 1: **PMCB** enabled.
- 2: **PMCB** enabled in extended mode. In this mode, **GCU** also transmits information not strictly required to management, but useful for external supervisory systems. You should use this mode only if needed, because it increases the data traffic on **PMCB** network.

If **PMCB** isn't used, it should be disabled in order to avoid that **GCU** triggers early warnings to show possible errors on the Can Bus line.

If **PMCB** is enabled, every **GCU** connected to mains indicates the “BUS OFF” status of the line Can Bus (non-working status) by triggering W200 early warning. Since **BTBCU** has two **PMCB** channels, can alternatively trigger W062early warning.

All **GCUs** connected to **PMCB** network are identified by an address: addresses should be univocal. If a **GCU** identifies another GCU with its same address, it will indicate this fact by triggering W201early warning (“address duplicated on **PMCB**”). Since **BTBCU** has two **PMCB** channels, can alternatively trigger W203 early warning.

GCU provides P.0452 parameter for selecting the address (it is the same parameter that defines the Modbus address for the mains serial port of **GCU**). On **MCU** P.3701 parameter is used. On **BTBCU** P.0801 parameter is used.

It is also possible (but not mandatory) to indicate how many **GCUs** are connected to **PMCB** network. In this way **GCU** can show an inconsistency by triggering W202 early warning (“incorrect number of **GCU**”): the presence of this early warning can be used in the system protection logics, see below). **GCU** provides P.0803 parameter to indicate how many generators are connected to **PMCB** network. By setting P.0803 to zero, **GCUs** will not perform any control about the real number of connected **GCUs**. If there are some **BTBCU** devices (connectors) connected to the network, it is mandatory to set P.0803 to 0 on all **GCUs**, because the real number of **GCUs** connected to **PMCB** network depends on the status of **BTB** switch. The latest **GCU** versions acknowledge the presence of **BTBCU** with **BTB** switch open and they automatically disable the W202 early warning.

Here below all logics managed by devices through **PMCB** network are described. Logics relevant to distribution of active and reactive power aren't described, since they are already set out in other paragraphs.

8.1 ESU

Among all devices connected to **PMCB** network, there is one of them (called ESU) that has special functions usually linked to synchronization/sharing of information with all the other devices. The selection of this device is automatic, it doesn't require any configuration.

If some **MCU** devices are connected within **PMCB** network, ESU is for sure one of them: it is the one with the lowest address (the address is configured on **MCU** with P.3701 parameter).

If, on the contrary, there are no **MCUs** in **PMCB** network, ESU is the **GCU** device with the lowest address (the address is configured through P.0452 parameter on **GCU**).

BTBCU devices never act from ESU.

If the currently selected ESU device is disconnected from **PMCB** network, another one will be promptly selected.

8.2 Synchronization of clocks

Clocks/calendars of all **SICES Srl's** device connected to **PMCB** network are automatically synchronized with those of **ESU** device (see 8.1). In case it is necessary to modify date/time, it is necessary act on **ESU** device only.

8.3 Propagation of parameters

Some configuration parameters are automatically shared on **PMCB** network among all the other **GCUs**. In fact it is enough to modify them on a **GCU** to have them modified also on all the other ones. It is advisable (but not essential) to modify these parameters on ESU devices. Involved parameters are:

- P.0259...P.0264 (**DST4602x**, connected to function CBE – see 7)
- P.0803
- P.0805
- P.0806
- P.0816 (**DST4602x**, connected to load function – see 8.6.1)
- P.0820 (**GC400x**, connected to load function – see 8.6.1)
- P.0822...P.0826 (connected to load function – see 8.6.1)
- P.0828 (connected to load function – see 8.6.1)
- P.0858, P.0860 (**DST4602x** and **GC400x**)
- P.1201...P.1207 (**DST4602x** and **GC400x**, connected to load reserve – see 8.6.2)
- P.1604…P.1654 (**GC400x**)

In case it is necessary to modify these parameters through the serial ports, always act on ESU device.

8.4 Authorizations for the closing of GCB

As to parallel systems among generators (not parallel with mains), it's fundamental to assure that two generators never close their own **GCB** switch at the same time without synchronization (because for sure they wouldn't be synchronized between them).

Let's suppose that two or more generators that are started simultaneously by means of a contact: there is the possibility (even if it is remote) that two of them take the same time to start and therefore they control the closing of the Switch **GCB** simultaneously (that will take place without synchronization, because up to that moment there hasn't been voltage on the parallel bars).

Through **PMCB** network, **SICES Srl's** devices prevent this situation: **ESU** device authorizes a single **GCU** at a time to close without synchronization of **GCB** switch. This function is automatic, it cannot be disabled and doesn't need any configuration.

This function is extremely safe if the number of **GCUs** connected to network **PMCB** (P.0803) is known. In this case, in fact, it is possible to configure the **GCUs** in order not to close its relevant **GCB** if the real number of connected **GCUs** doesn't match the configured one (dangerous situation: two **GCUs** not connected to the same **PMCB** network could close their **GCB** switches at the same time). P.0804 parameter allows to select:

- 0: the **GCUs** cannot close their own **GCB** if the real number of **GCUs** doesn't match the configured one (the default value is healthily advised).

- 1: the **GCUs** can close their own **GCB** even if the real number of **GCUs** doesn't match what configured.

Warning: if the number of **GCUs** connected to **PMCB** network (P.0803=0) is not configured, the system that authorizes the closing of **GCB** switches works in any case; it simply cannot consider **GCUs** that doesn't communicate any more on **PMCB** network as possible because of a failure of the communication cable).

8.5 Actions in case of GCB not open

For systems with parallel among generators (not in parallel with mains), if a generator that has to disconnect from parallel, cannot open its own **GCB**, it will be then dragged (by means of its alternator) by the other generators. This situation is dangerous (the dragged generator is damaged) and can be avoided in two manners:

- **Only for DST4602x**: if there aren't shutdowns, deactivations or discharges, by setting P.0243 parameter on "1", **DST4602x** will keep anyway the generator in action, therefore avoiding the dragging.
- It is possible to use P.0805 parameter:
  - If P.0805= "0", all the other **GCUs** open their own **GCB** switch, by avoiding, in this way, to drag the generator that has the failure on the switch (default value heartily advised).
  - If P.0805= "1": the closing of **GCB** switches isn't allowed, but neither the opening of the already closed **GCB** switches is forced.
  - If P.0805 = "2": no action. The opening of **GCB** switches isn't forced, and neither closing is forbidden.

8.6 Load Management

8.6.1 Load Function

This term indicates the capability of the system to automatically start/stop generators, so to have enough power (with a good margin, but not in excess) to supply users. So, this function has a meaning only when generators aren't connected in parallel with mains.

Only for **DST4602x** (starting from version 00.48) and on **GC400x**, this function allows to control the devices that work in parallel with the mains in "SYSTEM BASE LOAD" or with devices that work in "DROOP". **GCU** use the following logic to decide the management of the load on the gensets:

- If on Can Bus PMCB there are controllers that do not support the "SYSTEM BASE LOAD" mode, the load function is carried out only by isochronous gensets.
- If on Can Bus PMCB all controllers support the "SYSTEM BASE LOAD" mode, the load function is not only carried out by isochronous gensets, except the following cases:
  - If there are no digital input configured with the function DIF.2716 (it enables the load function in SYSTEM BASE LOAD): if all gensets are in SYSTEM BASE LOAD mode, all of them manage the load function.
  - If there are is a digital input configured with the function DIF.2716 (it enables the load function in SYSTEM BASE LOAD) and it is activated: if at least one genset is in SYSTEM BASE LOAD, the load function then is managed by the gensets in SYSTEM BASE LAOD.
  - If there are no digital input configured with the function DIF.2715 (it enables the load function in DROOP): if all gensets are in DROOP, all of them manage the load function.
  - If there are is a digital input configured with the function DIF.2715 (it enables the load function in DROOP) and it is activated: if at least one genset is in DROOP, the load function then is managed by the gensets in DROOP.

Gensets with "load function" enabled, on the contrary, can be automatically stopped (one at a time, according to appropriate logics) if the other generators are enough to supply the load; they will be immediately restarted (one at a time) if the load increases and then more power is required to gensets.

P.0821 parameter is used to enable the load function on a **GCU**:

- P.0821=0: “Load function” disabled.
- P.0821=1: “Load function” enabled.

  In this case, it is further possible to utilize a digital input to disable the "load function". Use DIF.2702 function (for **DST4602x and GC400x**) or DIF.0033 function (for **GC500x**):

  - If the input doesn't exist or it is active, the "load function" is enabled.
  - If the input exists but it isn't active, the "load function" is disabled.

Criteria for the automatic start/stop of generators are multiple and can be selected through P.0822 parameter

8.6.1.1 Priority on the base of the address

This operation is selected through values 1, 2 and 3 in the P.0822 parameter.

The operation logic is quite simple. Every **GCU** calculates the following values:

- ADPt value (kW). It is the power absorbed by the load and is calculated as sum of active powers supplied by all generators (ADPs).
- MDPt value (kW). It indicates the total rated power of supplying generators. It is calculated as the sum of the single rated powers (MDPs).
- MDPtn value (kW). It indicates the total rated power of supplying generators, save for the generator with less priority (see after). It is calculated as the sum of the single rated powers (MDPs).
- DPRt value. It is the ratio between ADPt and MDPtn: it indicates the percentage of power supplied by generators on the whole (that, thanks to the distribution of the load, is also the one supplied by each generator).
- DPRtn value. It is the ratio between ADPt and MDPtn: it indicates the percentage of power that generators would supply if the generator with less priority were stopped (see below).

The less "priority generator" among the supplying ones is stopped when the **DPRtn** value is lower than the threshold (%) set with P.0828 parameter (“deactivation threshold without interruption, for the time configured in P.0829 (“deactivation delay”).

In the same way, the generator with the higher priority among those stopped by the "load function" is started if the **DPRt** value is higher than the threshold (%) set with P.0826 parameter (“activation threshold”), without interruption, for the time configured in P.0827 (“activation delay”).

Warning: P.0826 threshold and P.0828 threshold should differ **only by the hysteresis** (%) desired to give to the system. For example, by requiring the intervention of a generator, when all the other ones are at 80% of their nominal power (P.0826 = 80), then the stopping of a generator will be needed, when, with the current load, generators that would go on supplying, would remain with a power lower than 75% of the rated one (P.0828). In this example a hysteresis of 5% has been used. P.0826 should be set on a value higher than P.0828.

P.0830 parameter allows setting a further delay: when a **GCU** closes its own switch, the “load function” is temporarily disabled for the first P.0830 seconds.

In the previous description, we talked of "generator with less priority". In fact the logic is based on the priority concept connected to single generators. Internally, the **GCUs** produce a list of generators, by placing generators with higher priority before. The list is made in the following way:

- Generators that cannot supply (when they aren't in automatic mode or have shutdowns, discharges or active deactivations or have the "inhibition to starting" activated, etc.) aren't inserted in the list because they cannot be started automatically.
- Generators that are already supplying and that have the "load function" disabled aren't inserted in the list because they cannot be stopped automatically. NB: the "load function" is disabled for **GCUs** in TEST or REMOTE START mode.
- The generator selected as "master" (most priority) is inserted in the first position of the list. The parameter P.0823 always includes the address (**PMCB**) of the generator currently selected as “master”.
- Generators available and with the "load function" enabled, that have addresses higher than the "master" generator, are inserted in the following positions of the list.
- Generators available and with the "load function" enabled, that have addresses lower than the "master" generator, are inserted in the following positions of the list, in increasing order.

Let's give a practical example. Let's suppose to have 10 generators with addresses from 1 to 10 assigned to them. Generators with address 3 and address 5 are stopped **GCU** in OFF/RESET). The **GCU** of the generator 8 is in REMOTE START mode. The master generator currently selected is generator 4. The internal list of priorities will be the following one: 4 – 6 – 7 – 9 – 10 – 1 – 2.

When the "master" generator is changed, the list of priorities changes immediately. In this case, generators that have acquired "priority", but that are currently stopped (because before the change of the "master" were the ones with less priority), are started first. Then, if needed, the generators not required with less priority are stopped.

Warning: if there are some supplying generators with the “load function” disabled, and these generators are enough to supply the load, all generators with the load function enabled will be turned off, “master” generator included.

DST4602x and GC400x allow a further customization through P.0816 parameter (**DST4602x**) or P.0820 parameter (**GC400x**). That allows indicating a minimum number of generators that should be kept in action, even if all of them aren't necessary to supply the load.

The difference among the three modes described below consists in the criterion used to select the "master” generator.

It is also possible to select the “master” generator by activating a digital input, configured with DIF.2121 (for **DST4602x and GC400x**) or DIF.0062 (for **GC500x**) functions. The **GCU** with the input activated is automatically selected as the "master" one. The input has not to be activated on more than one **GCU**, otherwise the "master” generator will go on changing among **GCUs** with active inputs. When an input is not active, it will not be possible to modify P.0823 parameter (because it is immediately rewritten): the description present in the following three paragraph cannot be applied.

DST4602x (starting from version 00.48) and **GC400x:** it is possible to activate a digital output to indicate that the genset is selected as “master” by using AND/OR logics with the internal status ST.176.

8.6.1.1.1 Manual selection of master generator (1)

Manual selection of master generator (1). In this mode, it's up to the operator to change the "master" generator manually, by acting on P.0823 parameter.

8.6.1.1.2 Selection in rotation of the master generator (change at established time) (2)

In this mode, the **GCUs** provide autonomously to select a new "master" generator (by varying P.0823 parameter) once a day. P.0824 parameter is used to select the time for the change of the “master” generator. The new "master generator" will be the one immediately subsequent to the previous one among generators included within the list of priorities. In the example at the paragraph 8.6.1.1, after generator 4, generator 6 will be selected as the master one. It is still possible to change manually P.0823 parameter.

8.6.1.1.3 Selection in rotation of the master generator (change every x hours) (3)

In this mode, the **GCUs** provide autonomously to select a new "master" generator (by varying P.0823 parameter) when "n" hours are elapsed from the previous change. With P.0825 parameter it is possible to select every how many hours the "master" generator has to be changed. Warning, they are watch hours and not working hours of engines. The new "master generator" will be the one immediately subsequent to the previous one among generators included within the list of priorities. In the example at the paragraph 8.6.1.1, after generator 4, generator 6 will be selected as the master one. It is still possible to change manually P.0823 parameter: but you should bear in mind that the counting of hours restarts every time that the "master" generator is changed.

8.6.1.2 Optimization of generators (minimum nominal power).

This mode is available only on **DST4602x and GC400x**.

This mode is selected with the value “7” in P.0822 parameter.

This mode assures that the sum of nominal powers of started generators is the lowest possible that can supply the load. This independently from the “master” generator (P.0823 not used) and from the addresses of **GCUs**. This function works with a maximum of **five generators** "included" in the load function.

Let's suppose to have a 100kW, a 300 kW and a 700 kW generator, if the load were 300kW, 100kW and 300kW generators would be started: in fact the sum of nominal powers is 400kW, that is higher (with a bit of margin) than the load power. In case there were two or more combinations of generators with the same sum of nominal powers, the combination with a lower number of generators would be privileged: let's suppose that there are three generators, a 100 kW, a 200 kW and a 300kW generator, if the load were 250 kW, the 300kW generator would be started and not the couple 100 + 200.

P.0826 and P.0828 thresholds are anyway used to select the best combination of generators. P.0827 and P.0829 delays are anyway used before changing the combination of generators needed to supply the load. P.0816 parameter (**DST4602x**) or P.0820 parameter (**GC400x**) allows deciding whether it is possible or not to turn off all generators with the "load function" enabled, if all generators with the "load function" disabled are able to supply the load:

- P.0816=0: all generators with the "load function" enabled, can be turned off.
- P.0816 >0: at least one generator with the "load function" enabled should stay in action.

8.6.1.3 Optimization of generators (minimum number)

This mode is available only on **DST4602x and GC400x**.

This mode is selected with the value “7” in P.0822 parameter.

This mode assures that the minimum number of generators that can supply the load is started. That independently from the “master” generator and from the addresses of the **GCUs**. This function works with a maximum of **five generators** "included" in the load function.

First of all the function evaluates whether a single generator is able to support the load (starting evaluating them from the less powerful to the most powerful one). If no generator is able to support the load, then the function evaluate all combinations of two generators (always by trying to privilege of all less powerful generators first). If no couple can support the load, then it tries with three generators and so on. As to the example of the previous paragraph (a 100kW, a 300kW and a 700 kW generator), if the load were 300 kW, the 700kW generator would be started, because is the only one able to support the load by itself (with a bit of margin).

P.0826 and P.0828 thresholds are anyway used to select the best combination of generators. P.0827 and P.0829 delays are anyway used before changing the combination of generators needed to supply the load. P.0816 parameter (**DST4602x**) or P.0820 parameter (**GC400x**) allows deciding whether it is possible or not to turn off all generators with the "load function" enabled, if all generators with the "load function" disabled are able to supply the load:

- P.0816=0: all generators with the "load function" enabled, can be turned off.

- P.0816 >0: at least one generator with the "load function" enabled should stay in action.

8.6.2 Power reserve

This function is available only on **DST4602x and GC400x**.

The function "power reserve" is a function that works in addition to (not alternatively) the “load function”; it can be used only if P.0822 parameter is set on 0, 1 or 2. Its aim is to assure, in a certain moment, which generators, in that supplying moment, can support a certain number of kW in addition to those they are already supplying, in view of the connection of a big load of known power.

In practice, if the operator is already informed about the necessity to connect a load of “500 kW” to generators, the same will activate this function in advance by demanding a power reserve, for example, of “600 kW”, will wait until the system indicates that the generators are ready to support further “600 kW”, then will connect the load. After having connected the load the operator can disable this function.

Of course this new function will start/stop generators so to assure that the supplying generators can support a further power equal to the one of the selected by the operator.

The "power reserve" works together with the "load function" according to the following logic:

- A generator is started **when at least one** of the two functions requires its starting. So, if the generators are working at a percentage power higher than the one set in P.0826 or if the power that generators can further supply (sum of rated values minus the sum of supplied active powers) is lower than the needed reserve.
- A generator is stopped **if both functions** control the stop. So, if generators (excluding the less priority one) are functioning at a percentage power lower than the one set in P.0828 and if the power that generators can further supply (sum of rated values minus the sum of supplied active powers) is higher than the needed reserve.

The function "power reserve" can be configured with the following parameters:

- P.1201 and P.1202: thresholds in kW relevant to the first "power reserve" level.
- P.1203 and P.1204: thresholds in kW relevant to the second "power reserve" level.
- P.1205 and P.1206: thresholds in kW relevant to the third "power reserve" level.
- P.1207: select a "power reserve" level:
    - 0: "power reserve" function disabled.
    - 1: "power reserve" function enabled on thresholds P.1201 and P.1202.
    - 2: "power reserve" function enabled on thresholds P.1203 and P.1204.
    - 3: "power reserve" function enabled on thresholds P.1205 and P.1206.

The operator has the possibility to set three different "power reserves" and the select them simply by changing P.1207 parameter (that can be modified also through the serial ports, therefore also from remote). These parameters are automatically shared among the **GCUs**; so, by varying a parameter on a **GCU**, it is automatically modified on all the other ones.

For any level of "power reserve" there are two thresholds, in order to have a minimum of hysteresis. The logic is the following one:

- In a specific moment, the system calculates:
    - Sum of nominal powers of all supplying generators (MDPt).
    - Sum of nominal powers of all supplying generators safe for the less priority one (the one that should stop if the load status allows that) (MDPtn).
    - Sum of active powers of all supplying generators (ADPt).

- The load that generators can still support (**RESt** = MDPt – ADPt).
- The load that generators could still support if the one with less priority were stopped (**REStn** = MDPtn – ADPt).

- Supposing that the first level of "power reserve" is selected (P.1207 = 1):
  - A new generator is started if RESt < P.1201 for the period of time configured with P.0827.
  - The less priority generator is stopped when REStn > P.1202 for the time configured with P.0829.

Therefore, parameter P.1202 should be always set on a value higher than P.1201 (and the same is valid for the other couples of parameters): if we set P.1201 to “200 kW”, a new generator will be started in the event that the already supplying ones cannot support further “200 kW”, but afterwards this generator will be stopped only when the system calculates that without it the remaining generators can support, for example, further “220 kW”. Without this hysteresis, even a variation of just 1 kW of the load could continuously start/stop generators.

A "power reserve" level is considered valid only if both its parameters (P.1201 and P.1202 for the first level) are different from zero and if the first one is lower than the second one. In case a non-valid "power reserve" level is selected, the function will be disabled.

The operator has the possibility to select the desired "power reserve level" through contacts, too. **GCU** provides, for this purpose, the following functions for the configuration of digital inputs:

- DIF.2330: it disables the management of the "power reserve". When this input is active, **GCU** forces parameter P.1207 on "0”, which then is passed to the other **GCUs**, deactivating in this way, on all generators, the "power reserve".
- DIF.2331: it selects the first level of "power reserve". When this input is active, **GCU** forces the P.1207” parameter to "1", that then is passed to the other **GCUs**, activating in this way, on all generators, the "power reserve" on the first level.
- DIF.2332: as the previous one but for the second "power reserve" level.
- DIF.2333: as the previous one but for the third "power reserve" level.

In case more inputs are active at the same time that with the code of the highest function "wins".

Moreover, **GCU** allows using its digital outputs to show externally this function status. Therefore, it provides the following codes for the configuration of the digital outputs:

- DOF.3180: the output activates to indicate that no "power reserve" level is selected.
- DOF.3181: the output activates to indicate that the first "power reserve" level is selected.
- DOF.3182: the output activates to indicate that the second "power reserve" level is selected.
- DOF.3183: the output activates to indicate that the third "power reserve" level is selected.
- DOF.3184: this output activates to indicate to the operator that generators can support the presently selected "power reserve". The output is turned off during the phases of starting, connection in parallel and of power load of needed generators, it only activates when generators are in parallel out of loading phases and can support the needed "power reserve".

For **DST4602x** (starting from version 00.48) and **GC400x**, it is possible to know if the gensets are able to support the “power reserve” currently selected also by reading the Modbus register INPUT REGISTER 95.

Therefore, if needed, it is possible to install the panel keys that allow to select or disable the "power reserve". Keys can be also luminous (by utilizing outputs configured with DOF.3180 …DOF.3183

functions). Furthermore, it is possible to install on the panel a light that indicates when it is possible to connect the required load to generators (by utilizing the configured output with DOF.3184 function).

By installing keys (and not one selector), there is the advantage to have identical panels and therefore to select the "power reserve" on any of them. Moreover, since they are keys, usually they are not active and therefore the operator has also the possibility to select a different "reserve" level from the serial port or from parameters of one of the **GCUs**.

Alternatively, a selector can be installed, but it should be installed on a single panel: if it were installed on each panel and the operator selects different level of "reserve" among the different selector, the system wouldn't work. Moreover, since the selector will steadily activate one of **GCUs**' inputs (and therefore a "reserve" level will be constantly selected), the operator will not have the possibility to select a different "reserve" level from the serial port or from parameters of one of the **GCUs**.

8.6.3 Genset start

Usually, the load function starts only one genset at a time, when the power supplied by the other gensets remains higher than the threshold P.0826 for the time P.0827.

The logic is different if starting with a no gensets supplying. In this case, usually all gensets available are started: the load function itself will then stop (one at a time) all unnecessary gensets. For **DST4602x** (starting from the version 00.48) and **GC400x**, the behaviour is different if the load function works on gensets in “SYSTEM BASE LOAD” or “DROOP” mode:

- “SYSTEM BASE LOAD”: the gensets number configured in P.0816 (for **DST4602x**) or in P.0820 (for **GC400x**) are started.
- “DROOP”: the gensets number configured in P.0816 (for **DST4602x**) or in P.0820 (for **GC400x**) are started if there is voltage on the parallel busbars; otherwise, all gensets are started.

8.6.4 Genset stop

The load function commands the stop of one genset when the other gensets are able to supply the load. if it is required to stop the genset in another way (for example with a digital input that inhibits the starting), the load function immediately starts a new genset (if needed), but it does not stop the genset.

For **DST4602x** (starting from the version 00.48) and **GC400x**, another function has been added. If one genset has to open its own GCB, but not because of alarms of deactivations (so it doesn’t have to do it immediately), it is immediately excluded by the load function: in this way, the load function itself possibly starts new gensets, which will have to supply the power currently supplied by it. Only if the remaining gensets are able to supply the load (at the end of the power ramp) or if there aren’t other gensets to start, GCU will proceed to unload the power (if possible) and open the GCB. Anyhow, there is a time of max. 30 seconds for this function: after said time, the genset unloads the power and opens the GCB. Note: this function is only activated if all controllers connected on PMCB support it (so far, only **DST4602x** with software 00.48 or following or **GC400x**).

8.7 Devices on network PMCB.

As already said above, it is possible to connect three categories of devices to network **PMCB**:

- **GCU**. The network supports up to 24 GCU: but the limit will be reduced to 16 **GCU** if **only GC400x or GC500x** are used.
- **MCU**. Mains supports up to 4 **MCUs**.
- **BTBCU**. Mains supports up to 8 **MCUs**.

8.7.1 MCU devices

Please see MC100 technical manual for a detailed description of the device. Here it is essential to highlight only the two possible mode by means of which **MCU** can work with the **GCUs**:

- **Normal mode**. In this mode, single devices of **GCU** work according their own logics, simply by receiving from **MCU** information regarding the status of mains and **MCB** and **MGCB** switches. The only controls that **MCU** can send to **GCU** are synchronization controls, aimed to the closing of **MCB** and **MGCB** switches.
- **"GCUs controlled by MCU"**. It is possible to obtain this mode by activating the "inhibition to intervene" on **GCU** boards stably (through a contact, see 2.2). In this way, GCU cannot start/stop the generator on the basis of its own logics: on the contrary, **MCU**, through controls on network **PMCB**, will control start and stop of generators, according to its own needs. **MCU** controls the starting of a generator by forcing its relevant **GCU** in REMOTE START mode; it controls the stop by removing the REMOTE START request.

  MCU, in this mode, also manages active and reactive power setpoints during the phase of parallel with mains. Moreover, it is able to use the "load function" in parallel with mains, too (in order to utilize generators strictly necessary to supply the required power to the mains).
- Mains supports up to 4 **MCU**.

8.7.2 BTBCU devices

Please see BTB100 technical manual for a detailed description of the device.

- Mains supports up to 8 **BTBCU**.

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